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A SERIES OF TESTS of combined steel and concrete floor construction is to be made on Dec. 16, 17 and 18, at the works of the New York Sugar Refining Co., near the Long Island R. R. Depot, Long Island City, N. Y., and a general invitation to witness the tests is extended to all engineers and architects. The tests are to be made under the direction of Mr. Geo. Hill, M. Am. Soc. C. E. Over 80 different floor sections have been built covering a wide range of spans and using concreted mixtures made with various brands of cement and various cinder, gravel and broken some mixtures. The sections will be subjected to both concentrated and distributed loads to the breaking point. The tests will begin at 9 a. m. each day, and will continue until dark. The test sections are built from the same materials and in the same manner as the floors in the Sugar Refinery building, so as to represent actual working conditions, and sections of the floors in this building will also be tested.

THE NEW YORK RAPID TRANSIT COMMISSION has appointed a board of two civil engineers and one real estate expert to co-operate with Chief Engineer Parsons in preparing detailed contract specifications for the construction of the proposed rapid transit road. President Orr has appointed Mr. Geo. S. Morison, Past-President Am. Soc. C. E., and Mr. Howard A. Carson, M. Am. Soc. C. E., as the engineering members of the board, and Mr. James L. Wells as the real estate expert.

ELEVATED RAILWAY SUITS for damages are to be brought against the Union Loop Elevated Ry. Co., of Chicago, by property-owners along the line of the loop. The claims made are that the loop has driven away the carriage traffic of stores on Wabash Ave., and that many of the tenants of large buildings along the line will either leave or demand a reduction in rents, resulting in a depreciation of the property values and a lower class of tenants and stores, etc.

ADDITIONAL TRACK ELEVATION IN CHICAGO has been made necessary by a city ordinance passed Dec. 2. The work will include the first elevation work on the Chicago, Milwaukee & St. Paul Ry., extending from Central Park Boulevard to Irving Park Boulevard, and from North Lawndale Ave. to North Fortieth St., a total of seven miles. The Chicago & Northwestern Ry. will elevate three miles of line, from Diversey Ave. (where the present track elevation ends) to West Chicago Ave., which will make 14 miles of line elevated by this company. The new work will cost $2,500,000, and will substitute 59 subways for 64 grade crossings. The amount of elevation will be from 10 to 12 ft., with 12 ft. headway at all subways. The ordinance requires that work must be commenced by May 1, 1898, and completed within two years. It also provides that after the completion of the work the companies will be relieved from the operation of the ordinances regulating the speed or length of trains, the employment of flagmen, watchmen, signals, and the like. Any one trespassing on the elevated roadway when completed may be subjected to a fine of from $5 to $100.

BRIDGE RENEWAL WORK on the Atchison, Topeka & Santa Fe Ry. is being carried on very rapidly, at various points over the entire system of about 8,000 miles, and the work during 1897 will amount to about 7,000 tons. It includes steel trusses and plate girders to replace wooden bridges and old iron bridges. The plans are all prepared by the railway company's engineering department and the erection is done by the company's bridge gangs. The company maintains three permanent bridge gangs, composed of the best class of men, and finds the cost of erection work done in this way much more economical than if done by contract. The material is supplied by the American Bridge Works, of Chicago, and shipped direct on the railway company's cars over its own line. In preparing the designs special attention is given to securing an ample quantity of material and requiring as little field riveting as possible. In view of the great amount of bridge renewal work in prospect, it is proposed to prepare standard plans for plate girders and trusses of different spans and suitable for different localities, so as to reduce the amount of work in preparing separate sets of drawings for individual bridges differing but little from one another. All the designing, shop and erection work are under the charge of Mr. A. F. Robinson, M. Am. Soc. C. E., Bridge Engineer of the A., T. & S. F. Ry.

AN AMERICAN GRAIN ELEVATOR is being erected on the Manchester Ship Canal by Messrs. John S. Metcalf & Co., of Chicago, from the plans of Felix Miller, chief engineer. The storage capacity will be 40,000 tons of grain, stored in 226 wooden bins varying in capacity from 37 to 300 tons each. The exterior of the building will be brick. The elevator will be fitted with an unloading plant, with a capacity of 350 tons per hour, continuous weighing apparatus, Metcalf's patent dryers, and a plant for loading barges or ships at the rate of 150 tons per hour loose, or 250 sacks, if bagged. This grain is chiefly intended for the supply of the populous district around Manchester, and this city itself is the distributing center for a population of about 8,000,000. The present facilities for handling grain at this point are antiquated.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred Nov. 29 on the Santa Fe Pacific R. R. at Supai, Ariz. It appears that at this point a train composed of 25 loaded cars and 2 mountain engines got beyond control on a down grade owing to a failure of the brakes and jumped the track, afterwards catching fire. Three men were killed and two injured.

A SERIOUS RAILWAY ACCIDENT, resulting in the death of 11 persons and the serious injury of 22 others, occurred Nov. 30 at Warsaw, Russia. Dispatches say that owing to an error on the part of a signalman a heavy freight ran into a passenger train standing at the terminus.

TWO ELECTRIC CARS COLLIDED on the Detroit, Birmingham & Pontiac Suburban Electric Ry. Dec. 4, killing three persons and injuring about 20 others. The direct cause of the accident was ice and sleet on the rails, which permitted the two cars to descend opposite hills at high speeds and meet at the bottom. The indirect cause was some mistake in orders which caused the two cars to run in opposite directions on the same section.

A BOILER EXPLOSION at the Glenwood Coal Mine, Des Moines, Ia., Dec. 2, injured 22 men, 2 of whom are not expected to live, while 11 were seriously burned.

THE RAILWAY SAFETY APPLIANCE LAW of the state of New York was enacted in 1893, shortly after the passage of the national law, to reach such railways in New York as are not under the jurisdiction of the Interstate Commerce Commission, and is to take effect on Jan. 1. The State Board of Railroad Commissioners will hold a meeting in Albany, Dec. 21, to hear the railways petitioning for an extension of time within which to equip their freight cars with the safety appliances required by the law.

EXPERT TESTIMONY ON THE GARRISONS DISASter, in which six cars of a New York Central & Hudson River R. R. passenger train were precipitated into the Hudson River, killing 21 persons (Eng. News, Oct. 28, 1897), was taken by the New York State Railroad Commission at its final hearing on Dec. 6. Mr. Wm. Buchanan, the company's Superintendent of Motive Power, and Mr. P. H. Dudley, the well-known expert on railway rails, presented evidence to show that the derailment of the train was caused by obstructions placed on the track and by the rail joints having been tampered with, for the purpose of wrecking the train. Prof. Wm. H. Burr, M. Am. Soc. C. E., of Columbia College, and Mr. John Bogart, M. Am. Soc. C. E., who were employed by the railway company to investigate the accident, both testified that the amount of water coming down the mountain side and lodging behind the inshore track was not sufficient to deteriorate in any way the condition of the roadbed. A contrary view was taken by Assistant State Engineer Leutz, who was employed by the Railroad Commission to investigate the accident. Mr. Leutz stated that a careful measurement showed that the flow of water down the mountain side was 4,320 gallons each 24 hours. He found that this water had percolated through the embankment on its way to the river, and believed it aided to weaken it, although he would not say that it was sufficient to have caused the accident. The Commission announced that it would hand down its decision on the accident at an early date.

The inquest of the Coroner's jury into the cause of the death of the persons injured in this accident has resulted in the following verdict:

We, the jurors, agree that the persons came to their death at about 5:30 a. m. at an accident on the New York Central R. R. near Garrisons, N. Y., when six cars and engine plunged into the Hudson River, and that the nineteen persons were drowned, with the exception of one Williams, who came to his death from loss of blood and shock, and the cause of this accident is unknown to this jury.

All but one of the jurors agreed in this verdict, and this one brought in a supplementary verdict to the effect that the cause of the accident "was imperfect construction and maintenance at the particular place of accident."

LOCOMOTIVE ENGINEERS on the Central R. R. of New Jersey must not, after Jan. 1, 1898, be over 50 years of age to retain their places. The reason advanced is that there is too great public risk in retaining men over that age at such an important post. Those who have passed this age and are otherwise useful will be employed in some other capacity by the company.

A FAST RAILWAY RUN was made on the Pennsylvania line from Pittsburg, Pa., to Chicago, Ill., and return, on Dec. 2 and 3. The train left Pittsburg at 6:58 a. m. and arrived in Chicago at 5 p. m. the same day, making the total run of 468 miles in 602 minutes. The same train made the return trip from Chicago to Pittsburg in 565 minutes. Speed recorders were used and recorded the following high speeds: Between Liverpool, O., and Clark Junction, 8.1 miles, the time was seven minutes; between Wheeler and Valparaiso, Ind., 6.8 miles, the time was six minutes, and between Chicago and Hamlet, 57 miles, the time was 55 minutes. The train consisted of four private cars, and the object of the run was to ascertain the possibility of reducing the time of the Limited Express to 20 hours between New York and Chicago.

THE TORPEDO BOAT "WINSLOW" had its official trial trip on Dec. 1, and made 24.8 knots for two consecutive hours, with the tidal observations, not yet worked out, seemingly in her favor. The contract with the builder, the Columbia Iron Works, of Baltimore, required a speed of 24.5 knots for two hours.

THE 80-FT. YACHT "ELLIDE," built for E. B. Warren, Vice-President of the Barber Asphalt Co., from the plans of Charles D. Mosher, has made the astonishing record of 37.89 miles per hour. She thus beats the "Turbinia's" record of 37.7 miles per hour. The "Ellide" is 80 ft. long over all, 8 ft. 4 ins. beam and 3 ft. 6 ins. draft. She is of composite construction, with a double mahogany skin, fastened by Tobine bronze bolts, and steel frames and scantlings. Five steel bulkheads divide the hull into six water-tight compartments, and there are in addition a number of copper air-tanks. The motive power is a quadruple expansion engine, with 9, 13, 18 and 24-in. cylinders and 10-in. stroke. The Mosher boiler is practically that used in the new torpedo launches and in the submarine torpedo boat now building at the Columbian Iron Works, in Baltimore. The speed trial trip mentioned was made on the Hudson River over a mile course measured by the U. S. Coast Survey, and this distance was covered in 1.35 minutes.

A STEEL COASTING STEAMSHIP OF 5,000 TONS is being built at Chester, Pa., for the Alaskan trade. The plans call for a vessel 415 ft. long, 47 ft. beam and 27 ft. depth of hold, with a carrying capacity of 4,200 tons of coal and cargo. When completed she will ply between Seattle and St. Michael's, Alaska, at the mouth of the Yukon River. From that point a line of river steamers will run to Dawson City. The journey from Seattle to Dawson would thus be covered in 20 days.

A STEEL BARGE LINE ON THE MISSISSIPPI RIVER, running between St. Louis and New Orleans, is being actively promoted. The claim is made that while the lowest grain rate from Chicago to tidewater is now 6.6 cts. per bushel, the steel barges would do this work, from St. Louis to New Orleans, for 3 cts. per bushel. The sum of $500,000 is to be first raised and with half of this sum three experimental barges and a tow-boat will be provided.

NAVIGATION ON THE NEW YORK STATE CANALS was closed on Dec. 1 and contract work on the improvements are again commenced.

A MUNICIPAL GARBAGE PLANT IN MILWAUKEE is proposed; 5% bonds to the amount of $120,000 for that purpose were sold to R. L. Day & Co., of New York city, a few days ago. Work cannot proceed at once, however, owing to some question regarding the legality of the bond issue. Mr. Wm. J. Fiebrants is Comptroller of Milwaukee.

REMOVAL OF GRADE CROSSINGS AT ELIZABETH, N. J., BY THE PENNSYLVANIA R. R.

In our issue of June 1, 1893, a detailed description was made of the work then in progress for eliminating the dangerous grade crossings of the Pennsylvania R. R. and the Central R. R. of New Jersey, at Elizabeth, N. J. The Pennsylvania R. R. Co. undertook to elevate its four tracks at this point for a distance of about 1.8 miles, and also to build a new station for Elizabeth, at a cost of somewhat over $300,000. This work was successfully completed about two years ago, upon plans prepared by Mr. Wm. H. Brown, chief engineer of the Pennsylvania R. R. Co., with Mr. Wm. C. Bowles as resident engineer.

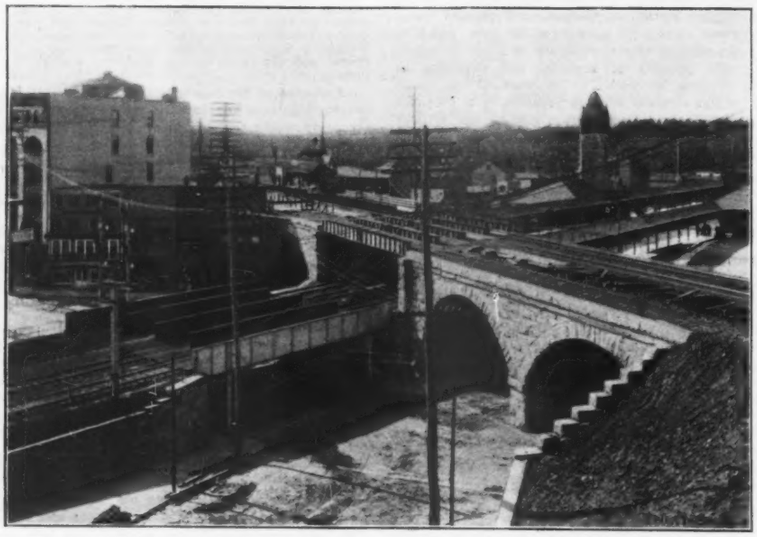


FIG. 1.—CROSSING OF THE PENNSYLVANIA R. R. OVER THE CENTRAL R. R. OF NEW JERSEY AND BROAD ST., ELIZABETH, N. J.

Plate-Girder Spans, 50 and 52 ft. Masonry Arches, 54.3 ft. span; 11 ft. 6 ins. rise.

Some excellent photographs of the finished work have been lately taken, and the character of the work performed is well shown in the several views selected for presentation in this issue. In all there are eight stone bridges, two of 40 ft. and six of 50 ft. span. These arches were built without interrupting traffic by constructing an arch for two tracks at a time, and then shifting the track connections while the other half was erected. For this purpose all skew arches were of the ribbed type, which readily lends itself to this method of erecting. Sandstone was used for the masonry. There are also six plate-girder spans; one 80 ft., two 30 ft., two 60 ft. and one of 50 ft. span. These girders are of the Pennsylvania R. R. Co.'s standard design for half-through girders; the span over the Central R. R. of New Jersey's tracks is shown in one of the illustrations. Between these bridges and arches the track is carried upon a substantial earthen embankment.

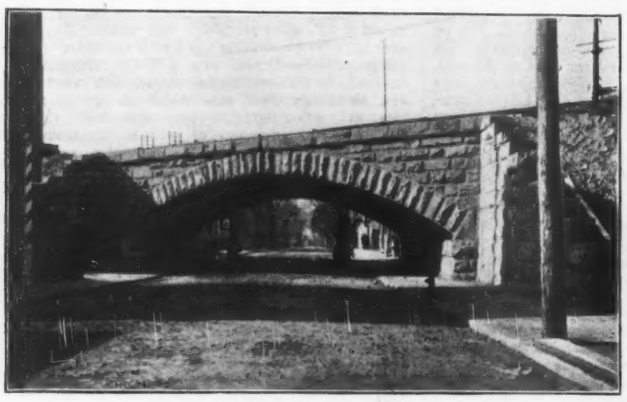


Fig. 2.—Arch at West Grand St.
Span, 62 ft.; Rise, 9 ft.

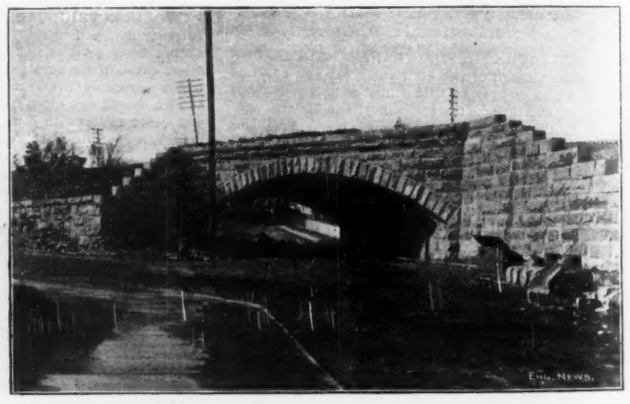


Fig. 3.—Arch at Rahway Ave.
Span, 50.2 ft.; Rise, 9 ft. 6 ins.

MASONRY ARCHES CARRYING THE PENNSYLVANIA R. R. OVER STREETS IN ELIZABETH, N. J.

REDUCTION IN COST OF STEAM POWER FROM 1870 TO 1897.*

By F. W. Dean, M. Am. Soc. M. E.†

In the year 1870 the most economical steam engine in use in mills was the Corliss simple condensing engine which used 19 or 20 lbs. of steam per HP. per hour. Previous to that time compound engines had been used in England in mill practice, and simple engines had in many cases been changed to compound. In this country compound pumping engines had been used to a very limited extent, notably the Worthington direct-acting duplex compound, the first one of which was put in at the Charlestown, Mass., water-works in 1863, and the installation of the Morris engine at Lowell, and the Leavitt engine at Lynn, are well-known examples of them in the early part of the period which we are considering. The Lowell engine was of the Simpson type, so-named from the Simpsons of London, who originated the arrangement of two compound cylinders with different lengths of strokes under one end of a beam. It is known as the Morris engine, from Henry G. Morris, the builder, but its design is due to the late Robert Briggs, of Philadelphia.

The Pawtucket pumping engine, built by Geo. H. Corliss, and started June 30, 1878, is another important example of economical pumping engines, and probably was the most economical steam engine which had been built up to that time, having used less than 14 lbs. of dry steam per I. HP. per hour. While these engines are not mill engines, they are influenced by the practice of builders of mill engines, and can properly be considered with them. Pumping engines have heretofore been the leaders in economy, but at present the best pumping and mill engines are practically equally economical. Of course, the greatest single step in economy was the introduction of the compound engine.

At the present time we may cite the Louisville pumping engine and several mill engines, one or more at Grosvenordale, Conn.; Natick, R. I.; West Boylston, Mass.; Berkley, R. I., and Lawrence, Mass., as being about on a par and representing the best commercial economy.

In 1873 the most economical compound engines used about 16½ lbs. of steam per I. HP. per hour, as shown by tests of the Lynn and Lawrence pumping engines, which then established new records for duty. Improvements in methods of using steam were made until it is now as easy to design an engine to use less than 13 lbs. of feed water per HP. per hour as it was to use as little as 16 lbs. in 1875.

At this date steam jackets were common, and were used in all engines which gave the most economical performances. The steps, however, that lowered the steam consumption of compound engines from 16 lbs. to 14 lbs. per I. HP. per hour, were largely the introduction of a cut-off on the low-pressure cylinder and a reheating receiver between the cylinders. Although the reheater was invented by the late E. A. Cowper, of London, in 1862, so far as I know, it was first used in this country by E. D. Leavitt in his engines for the Calumet & Hecla Mining Co., and is regarded by him as one of the most important causes of the economy of his engines.

These features appear to have been the principal means of lowering economy to 14 lbs. of steam; but to what are we to attribute the step to 13 lbs.? Clearance is well known to be an important factor, and its reduction, especially in the last cylinder of a series, is important for economy. It is receiving constant attention from careful designers, and its reduction is a constant source of gain.

The 13-lb. mark has also been reached by an increase in steam pressure with resulting increase in the number of expansions. In some cases a reduction in the size of the high-pressure cylinder has doubtless contributed toward economy, by means of which smaller surfaces are exposed to the boiler steam than would otherwise be the case. This carries with it a proportional reduction of initial condensation in the cylinder which is most prolific in this cause of waste.

Still further, the 13-lb. mark has, in general, been attained by engines which have a low-pressure cylinder larger for the work to be done than is commonly the case, so that the mean effective pressure referred to the low-pressure cylinder is in the vicinity of 21 lbs. There are occasional exceptions, as in the case of the Louisville engine, which worked with a mean effective pressure referred to the low-pressure cylinder of 25 lbs. Such cases are exceptional, and their economy can be attributed to great perfection of detail.

It will in general be observed, however, whatever may be said of other causes, that most of the extreme cases of economy are those in which a good vacuum has been maintained. This leads me to say that the importance of good vacuums is often not appreciated, and that air pumps and condensers are as often too small.

There is a strong tendency nowadays to underrate steam jackets, but I believe that in every case where they have been wasteful, or where their economy is indifferent, at all events with ordinary speeds, an examination would show that the jackets are air-bound, water-logged, blowing through traps, or that the jacket piping is bare, and thus steam for heating the building is charged to the engine. Such an arrangement of pipes can furnish but indifferent material for giving up latent heat to the working fluid within the cylinders, and is, in fact, absurd.

The effect of reheaters in drying out steam which issues from a preceding cylinder and in superheating it to 60° or 90°, as is often the case, for use in the next cylinder, cannot be otherwise than advantageous, for, as Professor Thurston shows in his paper of 1894 before this society, heat so added to the working fluid saves much more steam than was condensed to liberate this heat. While these considerations are very general, they are necessarily so, for nobody can attribute to any one of the features named its proper effect. Moreover, their combinations are very varied. Whatever may be said pro and con on this subject, it cannot be denied that the best results have been obtained from engines equipped with jackets and reheaters.

*Abstract of a paper presented at the New York meeting of the American Society of Mechanical Engineers.

†Mechanical and Mill Engineer, 53 State St., Boston, Mass.

Considering economies effected, it is safe to say that, without including triple-expansion engines, steam economy has steadily decreased from 20 lbs. to 12½ lbs. per indicated horse-power between 1870 and 1897. This corresponds to a saving of $(20 - 12½) \div 20 = 37½\%$.

Within this period of 27 years the use of exhaust steam has extended in various mills, such as cotton, woollen, and paper mills, so that in some mills the cost of steam power is next to nothing.

Economies of this kind are not confined to the use of the exhaust of non-condensing engines, for since 1895 the writer's firm has had installed at the Washington Mills, Lawrence, Mass., a large surface-condensing vertical compound engine, the rejected heat of which is utilized. In this mill large quantities of warm water are used in the dye-house, which has heretofore been heated by exhaust and direct steam. Now the circulating water of the new engine is sent from the condenser to the dye-house by the circulating pump at about the temperature required. In this case the rejected heat of the engine is just as effectively used up as it would be if the engine were non-condensing and sending its exhaust to the dye-house. There are advantages, moreover, in the compound surface-condensing engine, for there is less rejected heat to use, with consequent diminished chance for waste, and there is less heat lost by radiation from a pipe full of warm water than from one full of steam. This constitutes one of the latest forms of recent economies. It may be mentioned incidentally that by the surface-condensing engine,oil is kept out of the dye-house and away from the cloth. The air-pump discharge, being small in volume, and containing all of the cylinder oil, can be easily taken care of in any way which appears to be advantageous.

What is there to be said concerning boilers within the period that we are considering. The horizontal return tubular boiler is still the standard of the country, and will probably so remain. It is cheap, and, if properly built, it is safe. As its tube-heating surface can be effectively blown with steam with the certainty that the jet will strike every part thereof, and as, furthermore, its tubes can be effectively scraped at any time without taking the boiler out of service, it must necessarily be more economical than any of the numerous water-tube boilers which are now being introduced. The fire surfaces of the latter can only be indifferently blown, and they cannot be scraped at all unless the boiler is cooled down, and in general it cannot then be done with anything approaching thoroughness. There is scarcely any improvement to be noted in the horizontal return tubular boiler during the last 27 years as far as economy is concerned, but I believe that grates have been improved to a measurable extent, resulting in an economy of perhaps 2%.

My own experience teaches me that the internally fired boiler, either of the locomotive or vertical type, will save under equal conditions some 7% of coal compared with the horizontal return tubular boiler, besides causing an important economy in doing away with brickwork. Mr. Bryan Donkin, in a recent paper before the Institution of Civil Engineers, in discussing boiler economies, says: "Generaly speaking, internally fired boilers give a higher efficiency than those externally fired. The old and well-known locomotive type, with smoke tubes and induced draught, stands high as a very economical steam generator." Such praise from so careful an investigator as Mr. Donkin should carry great weight.

Within 27 years economizers for heating feed water in smoke flues have become common. Although subject to a rather large depreciation, in the general case they will save about 7 or 8% of coal. There are economies to be obtained from the use of vertical engines. These come from reduction of friction, reduction of repairs to cylinders and pistons, and diminished cylinder oil consumption. It would not surprise me if there were a net saving of 5% by reduced friction of a vertical compound compared with a horizontal engine.

Summing up the various items that have been mentioned, the following may be presented as the economies of the period from 1870 to 1897:

Saving due to compounding, jackets, reheaters, higher pressures, and greater expansions..	37 %
Due to vertical engines.....	5 "
Due to vertical internally fired boilers.....	7 "
Due to economizers.....	7 "
Due to improved grates.....	2 "

As these economies could not be simultaneously applied to the original condition of a mill, their sum is not a result that could have been realized in any case.

With these important economies having been brought about during 27 years, the question arises, are there any compensating disadvantages?

It is easy to show that there are not, for—

First. The first cost of a cross compound condensing engine is no greater than that of a pair of simple condensing engines 27 years ago, on account of improved tools and processes and reduced prices of materials.

Second. Interest charges are less than they were 27 years ago.

Third. The depreciation of engines is less than it was 27 years ago, on account of better materials, better workmanship, better oil, and better means of applying oil. Vertical engines will render the depreciations of cylinders, pistons, piston rods, piston-rod packing, and crossheads less than similar parts in horizontal engines.

Fourth. The reduction in the number of boilers required by some 33% for a given power within 27 years carries with it many reduced charges, such as first cost, interest, repairs, depreciation, insurance, taxes, cost of boiler-houses, cost of attendance, and various lesser items.

Fifth. Present boiler-building practice is superior to the old, so that high pressures are now as safely and comfortably carried as the lower pressures of 1870. Better materials, longer plates, and fewer joints, but joints of high efficiency and maintaining the circular form with changes in pressure, drilled holes, hydraulic riveting, and round-tool caulking render it as safe to carry 200 lbs., or more as any lower pressure.

Sixth. I might include reductions in cost due to handling coal by conveyors for large plants and by mechanical stokers. Conveyors are in some cases very economical, but mechanical stokers are of doubtful value, speaking generally. The greatest efficiency of the conveyor is to be found in connection with the mechanical stoker.

So far the only steam engine considered is the compound engine. This engine has recently been found capable of utilizing the higher pressures much more economically than was formerly suspected. It has therefore diminished the advantage of the triple-expansion engine to such an extent that the latter has met with something of a setback. I believe, however, that the triple engine is still to be common when pressures begin to exceed 160 lbs. of steam, and its undoubted advantage at sea gives evidence that it will be no less on land. Within a year or two an interesting and instructive comparison can be made between two pumping engines, one compound and one triple, both to use 185 lbs. of steam and designed on the same lines by Mr. Leavitt.

It seems probable that the relative economies of the compound engine, using 160 lbs., and the triple, using 185 lbs. of steam, are to-day represented in the very best practice by 12¼ lbs. and 11¼ lbs. of steam respectively per indicated horse-power per hour. This corresponds to a saving of $(12¼ - 11¼ \div 12¼ = 8.16\%$, which is a paying saving.

Very careful attention should be paid to the kind of steam valves used in engine cylinders, for leaky valves can readily nullify the advantage which may be derived by anything which can be done to contribute to economy in the general design. It is the writer's experience that the gridiron valve, properly designed with ample lap, and originally made strictly tight by scraping, will remain so far longer than any other kind.

The future, so far as we can now see, offers us highly superheated steam for further means of economy. The technical papers have frequent accounts of the use of such steam in Germany, and published tests (see "Engineering," pp. 113, 391, 1895) show that a small Schmidt "motor" has used 10.17 lbs. of steam per I. HP. per hour. It would seem that we have a right to anticipate in the early future a steam rate of 10 lbs. by means of superheated steam in the best designed engines. Compared with the lowest rate thus far mentioned, this corresponds to a saving of $(11¼ - 10) \div 11¼ = 11.11\%$.

We have also in anticipation the use of very high steam pressure and quadruple-expansion engines as built experimentally at Cornell University and described by Professor Thurston last year before this Society. If, however, steam can be so highly superheated that expansion in one cylinder will not cause condensation, nor even the saturated condition until the time of exhaust, as was the case in the Schmidt motor, extreme economy may be obtained without resort to the multiple-expansion engine.

The economies thus far mentioned relate to improvements in engines and boilers; but one of the greatest economies results from the low cost of coal at present in Lowell, Lawrence, and similarly located towns.

The prices of coal in these places every five years were as follows:

Year.	Price.	Kind of Coal.
1870.....	$7.10.....	Anthracite.
1875.....	7.20.....	"
1880.....	4.75.....	Bituminous.
1885.....	4.25.....	"
1890.....	4.05.....	"
1895.....	3.85.....	"

These prices show a saving from 1870 to 1895 by themselves of about 46%.

I shall now consider the actual figures making up the cost of a mill steam plant, and its cost of operating, say, of 1,000 HP. in most mill towns in the State of Massachusetts away from tide-water. The very best steam plant of this power 27 years ago, including a pair of simple condensing engines using 20 lbs. of steam, boilers evaporating 8 lbs. of water on total coal used, buildings, chimney, and all accessories, cost $70 per I. HP.

The fixed charges on such a plant were interest at 6%, depreciation 4%, repairs 2%, insurance 1%, or a total of 13%.

13% of $70.00 is	$9.10
Coal at 2½ lbs. per I. HP. per hr., @ $7.10 a ton, $\frac{2½ \text{ lbs.} \times 10 \text{ hrs.} \times 308 \text{ days} \times \$7.10}{2,240} =$	24.40
Attendance, boilers { 3 day men @ $1.50, and 1 night man @ $1.50. } $\frac{\$6 \times 308}{1,000} =$	1.85
Attendance, engine { 1 engineer @ $3.00 and 1 assistant @ $2.00. } $\frac{\$5 \times 308}{1,000} =$	1.54
Oil, waste and supplies.	1.25
Total	$38.14

The very best plant of 1,000 HP. can be installed to-day complete, including buildings, chimney, compound engine using 12.5 lbs. of steam, boilers evaporating 9 lbs. of water on total coal used, economizers, and all accessories, for $57 per I. HP. Such a plant can run on 1.4 lbs. of coal per I. HP. per hour for total coal consumed. The fixed charges are interest at 5%, average depreciation 3½%, repairs 2%, insurance and taxes 1%, or a total of 11½%.

11½% of $57.00 is	$6.55
Coal at 1.4 lbs. per I. HP. per hr., @ $3.85 a ton, $\frac{1.4 \times 10 \times 308 \times \$3.85}{2,240} =$	7.41
Attendance, boilers { 2 day men @ $1.00; 1 night man @ $1.50. } $\frac{\$4.50 \times 308}{1,000} =$	1.39
Attendance, engine. { 1 engineer @ $3.50; 1 assistant @ $2. } $\frac{\$5.50 \times 308}{1,000} =$	1.69
Oil, waste and supplies	.80
Total	$17.84

Saving in 27 years:

First cost, $70 — 57 ÷ 70 = ... 18.6%

In operation, $38.14 — $17.84 ÷ 38.14 = ... 53%

On the supposition that superheated steam can reduce the steam consumption to 10 lbs. per I. HP. per hour, and that the combined efficiency of boilers and economizers is not affected thereby, the cost of installation of I. HP. can still be taken at $57.

The cost of coal per I. HP. will be:

$$\frac{1.11 \text{ lbs.} \times 10 \text{ hrs.} \times 308 \text{ ds.} \times \$3.85}{2,240} = \$5.88$$

Other charges will be..... 10.43

Total.. .. ..$16.31

This makes a saving of yearly charges, compared with the best present plant, of $(\$17.84 — \$16.31) \div 17.84 = 8\%$.

Some actual costs of a yarn mill in Massachusetts built in 1889 are as follows:

Cost per HP. of engine (compound)	$60.50
Total coal burned per year	2,674 tons.
Average I. HP. for the year	1,132 I.HP.
Total coal burnt for power, heating mill, and banking fires, per I. HP. per hour	1.75 lbs.
During the six months when no heating was done, the coal used per I. HP. per hr. was	1.65 lbs.

The cost of operating a horse-power per year was as follows, assuming 11½% fixed charges:

Total cost of plant, $66,600, at 11½%..	$7,659.00
Coal, 2,674 tons, at $4.75 per ton.....	12,701.00
Attendance $8.85 a day × 308 days.....	2,725.80
Oil, waste, and supplies.....	312.00
Total cost of power.....	$23,397.80
Average HP. per year.....	1,132 I. HP.
Cost per I. HP. per year.....	$20.67
Cost corrected for coal used in heating mill	$20.01

In order to place them in the pages of the Transactions of the Society, and as illustrating a recent steam-engine performance, I add the results of two trials of a high-class steam engine built within the last year. Considering the steam pressure used, it is the best performance of which I know. The engine is at the mills of the Atlantic Cotton Mills, Lawrence, Mass., and the trials were made on Feb. 17 and 18, 1897, by the writer. The engine was built by the McIntosh & Seymour Engine Co., of Auburn, N. Y., and is a vertical cross compound having its shaft a part of the water-wheel shaft. It is provided with gridiron inlet and exhaust valves on both cylinders, and auxiliary cut-off valves of the same kind on both cylinders. The valves have positive motions throughout, and the points of cut-off are determined on both cylinders by a shaft governor.

The high-pressure cylinder is jacketed throughout by steam of boiler pressure, and there are reheating coils in the receiver, through which live steam of boiler pressure circulates. The low-pressure cylinder is unjacketed. During both tests the condensations from the jacket and reheater were weighed together on platform scales, the amounts of which are stated below. The temperature of the condensation was determined some 30 ft. from the reheater. The boilers supplied steam to nothing but the engine.

The engine was taken in its every-day working condition, and the results are, so far as I can see, being duplicated in regular operation.

In the table it will be noticed that the temperature of the injection and feed waters is stated as 32° Fahr. It was determined by five different high-grade thermometers, all of which gave the same result. The water in the river and canal, from which these waters came, was covered with ice, its temperature must have been almost exactly 32°.

The following are the leading dimensions of the engine, and the result:

Diameter of the high-pressure cylinder	24.031 ins.
Low-pressure cylinder	48.031 "
Each piston rod	5.00 "
Stroke of each piston	48.00 "
Revolutions per minute	about 100 revs.

	First trial.	Second trial.
Duration of trial	5.079 hrs.	5.583 hrs.
Average temperatures (Deg. F.)		
Engine room	65	65
Steam near h.-p. cylinder 359	371	
Near low-pressure cylinder..312	309	
Jacket and reheater drain.....342	341	
Injection water	32	32
Condenser discharge	56	66
Feed water before entering htr	32	32
After leaving heater	94	101

Average Pressures.				
Atmosphere by barometer....	14.67	lbs.	14.62	lbs.
Steam at engine by gage	123.00	"	123.00	"
Initial in L.-p. cyldr abv atmosphere from indcator digrms.	10.00	"	14.50	"
Vacuum by test gage.....	28.00	ins.	27.10	ins.
Mean effective pressure in h.-p. cylinder	33.69	lbs.	43.92	lbs.
L.-p. cylinders	11.19	"	13.91	"
Reduced to L.-p. cylinder..	19.61	"	24.89	"
Superheat.				
Superheat near h.-p. cylinder.	7.5	deg.F.	20	deg.F.
L.-p. cylinder	74	"	61	"
Powers.				
Power developed by h. p. cyl.	385.2	HP.	470.6	HP.
By L.-p. cylinder	492.9	"	605.8	"
Total HP.	858.1	"	1,076.4	"
Steam Used by the Engine.				
Per cent. of jacket and reheater steam to total used	10.4	%	9.8	%
Actual weight of total steam used per I. HP. per hour..	13.01	lbs.	12.76	lbs.
Corected for superheat	13.05	"	12.87	"

The results on the two days furnish some interesting data in relation to the falling off in economy of a compound engine when it is underloaded. Taking the results of the second test as a standard, the load on the first day is 20% less, while the steam consumption is but slightly over 1% more.

Saving by the Feed-Water Heater.

The average increase in feed-water temperature caused by the heater, for the two days is 65½°, which, under the present conditions of temperature and steam pressure, is equivalent to a saving in coal of 5.6%.

TWO NEW GEARED LOCOMOTIVES.

(With full-page plate.)

Geared locomotives are used somewhat extensively in this country, but are mainly comparatively small engines for logging and mining railways having heavy grades, sharp and irregular curves, and rough track, though some few have been built of considerable size. These locomotives may be divided into two classes: First, those having a side shaft outside the wheels and gears carried on the faces of the wheels; and, Second, those having a central shaft with gears carried on the axles. In another column we have briefly discussed these two classes, and the general question of the use of geared locomotives. The Shay engine, of the side-gear class, has already been described and illustrated in our columns (Eng. News, April 26, 1890, and July 19, 1894), and in the present article we describe two types of engines of the central-gear class.

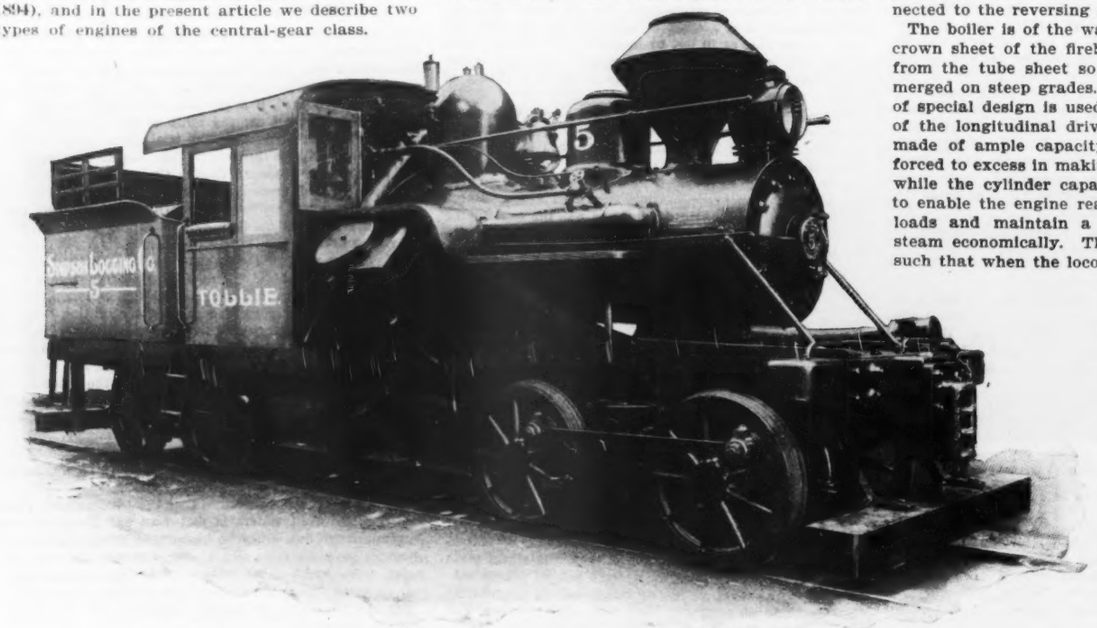


FIG. 6.—HEISLER TWO CYLINDER GEAREDLOCOMOTIVE FOR LOGGING PURPOSES.

The first of these engines was designed by Mr. Charles Heisler, consulting engineer, 136 Liberty St., New York city. It is claimed that this design possesses an efficient arrangement of gearing, and an unusually flexible wheel base, combined with high power and good facilities for inspection and repairs, while the flexibility of the wheelbase and the central position of the driving gear will reduce the internal friction and the wear of the gearing, wheel flanges and rails.

Some of these engines have been built for logging roads in the United States and in Mexico, and a 30-ton engine is now in operation on the Mill Valley & Mount Tamalpais Scenic Ry., a line 8.25 miles long, which ascends Mount Tamalpais (near San Francisco), with grades of 5 to 7%, compensated for curves. There are about 275 curves on the line, all of 70 to 75 ft. radius. This engine has one truck under the boiler and one under the coal bunker behind the cab. The engines were built by the Stearns Mfg. Co., of Erie, Pa., which is now completing a second 30-ton engine and a 60-ton engine with three trucks for the McCloud River Ry., on Mount Shasta.

The general arrangement of the driving mechanism is shown in Fig. 1. On the outer axle of each truck, which is of extra size, is secured a bevel spur wheel (A), gearing with a bevel pinion (B), whose shaft (C) is carried by a long bronze bearing in a frame forming part of the enclosing gear case (D). This frame is supported by a bronze-lined sleeve on the axle and is entirely independent of the truck frame, thus maintaining the gears in proper alinement, while the truck frame is relieved from the vibration and twisting strains due to the use of gearing. The gear case (D) forms a chamber in which the gears run in oil, and are thus protected from dust and dirt. The inner axle of each truck is driven from the main axle by means of coupling rods. The pinion shafts (C) (C) are connected by universal joints and horizontal shafts (D) (D) with the main crank shaft (E). All these shafts are under the boiler, on the longitudinal center line of the engine, and as the main shafts are above the axles of the wheels the pinion shafts are necessarily inclined, as shown. It will be seen that each connection includes one universal joint (between the intermediate shaft and pinion shaft) and one universal slip joint (between the crank shaft and intermediate shaft). For an engine with three trucks, or with a third driving truck under the tender, a slightly beveled gear on the main crank shaft drives an inclined intermediate shaft leading to the pinion shaft of the third truck, so that each truck is driven direct from the main crank shaft and not from another truck.

An ordinary locomotive boiler is mounted on the main frame, which is supported at each end by a swiveling driving truck, and the cylinders are mounted on the main frame at each side of the boiler. The cylinders are inverted and are inclined 45° in a vertical plane, transverse to the engine, the engines thus driving inward and downward upon the longitudinal crank shaft, as shown in Fig. 2. In the larger engines there are four cylinders, two on each side, and all are fitted with dished pistons and a metallic piston-rod packing consisting of alternate rings of babbit and iron, dovetailed together. Balanced slide-valves are used, only one of each pair being operated direct from the valve gear, the other being driven by a rocking lever mounted on the top cylinder heads and connecting the tail rods of the valve stems.

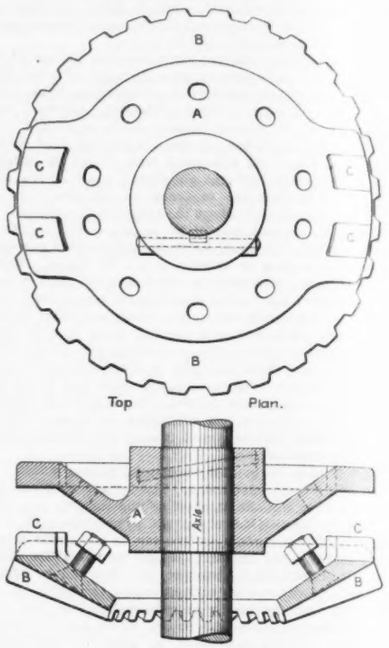


Fig. 5.—Bevel Gear Wheel for Heisler Geared Locomotive.

There is only one eccentric to each pair of cylinders, the eccentric carrying the two straps for forward and backward motion. The links are connected by rocker arms on a shaft, which is connected to the reversing shaft.

The boiler is of the wagon top pattern, and the crown sheet of the firebox is inclined downward from the tube sheet so as to be kept well submerged on steep grades. A drop-bottom ash pan of special design is used, dumping on either side of the longitudinal driving shaft. The boiler is made of ample capacity, so that it will not be forced to excess in making steam for severe work, while the cylinder capacity is sufficiently liberal to enable the engine readily to start its heaviest loads and maintain a good speed while using steam economically. The ratio of the gearing is such that when the locomotive is running at normal speed its engines will not be running at excessive speed or causing undue vibration. Fig. 3 is a detail of one of the trucks.

The universal couplings, Fig. 4, are of steel and phosphor bronze, clamped upon the shafts, so that they can easily be removed. They have little telescopic slip or angular movement, and offer a minimum of resistance to the swing of the trucks. These couplings are self oiling. The driving gear is composed of as few wheels as possible, and the gear wheels are made very heavy so as to sustain heavy shocks, even after they have become worn in service. The pinions are shrouded. The large gear wheels are built up of three parts each, as shown in Fig. 5. The cast steel base (A) is forced upon the axle by hydraulic pressure, and to this are bolted two plates (B) (B) in which the teeth are formed. Should a tooth be broken, the plate can be removed and a new one substituted by the engineman. The lugs (C) (C) on the plates fit into

slots in the base plate, thus relieving the bolts of all working strain. All the bearings have large surfaces and are fitted with ample oiling devices.

Fig. 6 is a view of one of the Heisler locomotives built for a lumber railway.

The second engine which we describe is also of the central-gear class, but has its mechanism arranged in a very different way. The cylinders are on each side, attached to the steel main frame of the engine, and are placed approximately in the same position as on ordinary locomotives, their center lines being parallel with the center line of the engine and track. The cylinders are inclined and the connecting rods are connected to crank pins in crank disks on each side of a transverse shaft under the main frame. On this shaft is a bevel wheel driving by means of bevel gearing a longitudinal line of shafting made flexible by universal couplings, and having steel bevel pinions which drive steel bevel spur wheels on the axles, every axle being driven directly by gearing. The main gearing is mounted on a short section of the central shaft, which is supported directly by the main frame. Each end of this is connected to a floating or intermediate shaft by a universal coupling, and the further end of each intermediate shaft is connected by a universal coupling and slip joint with a short shaft carried in bearings on the truck frame. The short shaft on each truck carries the two skew or bevel pinions between the axles, and the two spur wheels of each truck are placed on opposite sides of this section of the central shaft, so as to be revolved in the same direction. These locomotives are built by the Climax Mfg. Co., of Corry, Pa.

The Climax engine shown in Fig. 7 is one built for the Colorado & Northern R. R., a new line now under construction, which will have grades of 2 to 5%, combined with very sharp curves. It has three trucks, two supporting the main frame of the engine, and the third carrying the tender. Its weight in working order is 50 tons, distributed over a total wheelbase of 42 ft., the rigid wheelbase being only 3 ft. 8 ins. The wheels are 2 ft. 7 ins. diameter. Two 25-ton engines, having two trucks and no tender, have been built for the Lewisburg & Buffalo Valley Ry., in Pennsylvania, which has grades of 7% and curves of 20°. A number of these engines have been built for logging and general railway work, and the company also builds logging engines on the same

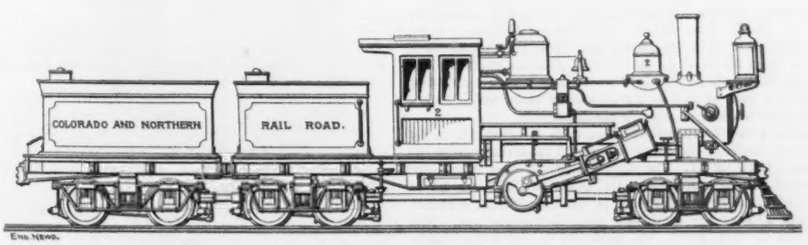


FIG. 7.—GEARED LOCOMOTIVE FOR THE COLORADO & NORTHERN R. R.
Climax Mfg. Co., Corry, Pa., Builders.

general plan, but with vertical engines and boilers, the engine driving a longitudinal crank shaft which drives the main longitudinal shaft by spur gearing. Two sets of gearing are used, a slow gear (about 8 to 1) for heavy work on steep grades, and a fast gear (about 3 to 1) for general work, giving a speed of about 15 miles per hour.

MULTIPLE-CYLINDER STEAM-ENGINES—EFFECTS OF VARIATION OF PROPORTIONS AND VARIABLE LOADS.*

By Robert H. Thurston,† M. Am. Soc. M. E., and Louis L. Brinsmade, Jun .M. Am. Soc. M. E.

The following paper is intended to exhibit the results of an experimental investigation of the relative efficiencies, with varying loads, of the ordinary high-pressure triple-expansion engine, of the compound of usual proportions at similar pressures, and of an intermediate type, already somewhat familiar to the engineering world, through the enterprise of a member of this Society mainly, in which the high-pressure element of the compound engine is made exceptionally small; the effect being, practically, that which would be produced by the suppression of the intermediate cylinder of the usual construction of triple-expansion machine. The machines employed in this research were, in fact, the available combinations of the largest of the triple-expansion "experimental engines" of Sibley College, and the combinations adopted were:

1. The triple-expansion engine in its usual condition.
2. The intermediate and the high pressure elements combined to make a compound engine of usual proportions—three to one.
3. The low and the high pressure elements combined to produce a compound of the peculiar sort above mentioned—seven to one.

The subject here taken up for investigation was first brought into view by the remarkable results reported by Mr. Rockwood to the American Society of Mechanical Engineers, as given by test of singularly proportioned engines, in which the total expansion was that made appropriate to pressures for which triple-expansion engines were customarily used, where great economy was sought, and yet in which he adopted a compound system having an abnormally small high-pressure cylinder. The economy reported for this case was both unexpected and unprecedented. The following study of the general case will show, at least in part, how this unexpected and singular result came about.

The characteristic feature of this new idea in steam-distribution was a large "drop" between cylinders. The Transactions for 1892, Vol. XIII., contain the first account of the results of experimental investigation of the relative value of the peculiar form of compound engine which it is the purpose of this paper to discuss.

The engine there described was a triple-expansion engine, built from the designs of Mr. Rockwood for the Merrick Thread Co., of Holyoke, Mass. The dimensions were 12, 16 and 24 13-32 ins. diameters of cylinder, 36 ins. stroke of piston for the high and intermediate cylinders, and 48 ins. for the low-pressure element. Receivers were placed between the cylinders, and the cylinders and receivers were jacketed. The machine was rated at 175 HP.

The results of test were reported as giving from 12.67 to 13.06 lbs. of feed-water per I. HP. per hour, with steam at 142 lbs. by gage. The best figure was given when developing 199 HP. When the intermediate cylinder was thrown out of action the best figure was 12.76 when developing 180 HP. The conclusion was apparently justified that the two forms of engine were of practically equal efficiency. The conclusion might further have been reached that, when costs are considered, the compound, as here proportioned, was the better of the two styles of engine. Still another conclusion would seem to be by this experiment fully justified; that the new system of proportioning the compound engine in decidedly the better where loads are in any considerable degree variable, as giving better opportunity to meet the demand for variable power with least sacrifice of thermodynamic and engine efficiency.

In the discussion of this power it was remarked by Mr. Cooper that "if two cylinders will secure an economy commercially equal to that obtained by the use of a greater number, then two cylinders are enough"—a conclusion which is axiomatic but none the less important. The true statement of the engineer's problem is always: What construction and what steam-distribution will give the largest return on the investment in building an engine to supply a specified amount of power?

The question which here arises is not at all whether two or three cylinders should be adopted in a stated case, but, and especially, whether, it being decided that, for business reasons, the compound is better than the triple-expansion machine, the two-cylinder compound should have the usual or an exaggerated cylinder ratio. The question is not whether a two-cylinder is better than a three-cylinder series-engine, but whether novel proportions are to be adopted with the older type of engine.

A comparison made by Mr. F. W. Dean, of the performance of an engine designed by Leavitt with one designed by Rockwood, the one having a cylinder ratio of four to one, the other of seven to one, later gave rise to further and interesting discussion.

The following are the principal data, as collated by the writer, at the time, in discussion of the paper:

Case of Compound vs. Triple and Hermaphrodite.

Engine.	Leavitt.	Rock-wood.	Rey-nolds.
Number of cylinders in series ..	2	2	3
Steam pressure, absolute	151.6	175.5	135.45
Vacuum, in. mercury	27.75	25.3	27.6
Ratio of expansion	20.40	33.(nom.)	19.55
Revolutions per minute	18.57	76.4	20.31
Length of stroke, ft.	10.0	4	5
Piston speed, per minute, ft	371.5	611.2	203
Cylinder ratio	4	7	1, 3, 7.
Drop between cylinders	None.	14 lbs.	None.
Dry steam, per I. HP. per hr...	12.156	12.84	11.678
Difference favoring Leavitt, 0.684 lbs. = 5.3%.			
Difference in favor of triple: Leavitt, 0.478 lbs. = 4%; Rockwood, 1.16 lbs. = 9%.			
	a	b	c
St. cons. reduced to 175 lbs.....	11.8	12.84	11.16
Comparative effic. on this basis	0.95	0.87	1.00

The table contains, in the last two lines, figures now added to bring into a more perfect comparison the relative economy of the several types of engine. Taking the best performance of the ideal engine as varying as the logarithm of the pressure employed, as also found by experience to be approximately the fact with good engines, the gain to be fairly anticipated by adopting the higher pressure, other things equal, should be such as to give the figures 11.8, 12.84, and 11.16 lbs. of feed-water per HP. per hour, for the three cases respectively. The relative efficiency will then be expressed by the figures 0.95, 0.87, 1.00. The engine of usual type, as a compound, when well designed and built, thus gives a performance within 5% that of the best known triple-expansion engine; the compound, with exaggerated cylinder-ratio, lacks 13% of the efficiency of the triple-expansion and 7% that of the standard type of compound. Leavitt's Chestnut Hill engine, for which the figure 11.2 is reported, may be taken as identical with the Reynolds pumping engine in relative efficiency; correction being made for difference in pressures. Were corrections made above for differences in ratios of expansion, the result above indicated would have been somewhat more marked, as the engine of novel proportions has, nominally at least, 65% higher ratio than its rivals; but, as a considerable part of this apparent expansion-ratio measures free expansion without performance of work, the comparison on this basis would not be strictly correct. No correction is attempted for differences in speeds of piston or of revolution, on which score the intermediate type of engine would apparently have a very marked advantage; for, as was long ago pointed out by the writer, where jacketing is adopted successfully variation of piston-speed seems to have little effect on economy.

The deduction from the above comparison would seem, unquestionably, to be that the long-standard type of multiple cylinder engine is a more economical machine than that in which the cylinder-ratio is exaggerated so greatly as to produce an unusual drop of steam-pressure between cylinders and an apparently highly increased expansion ratio. A priori, it would seem to be obvious that that engine which, with equal wastes of heat and steam and mechanical energy, in other respects produces the closest approximation to the ideal steam-distribution, which gives the most perfect reproduction of the ideal thermo-dynamic indicator-diagram, would exhibit maximum efficiency. The engines of Leavitt and of Reynolds are designed with the intent of reproducing a specified diagram, as laid down upon the drawing board of the designer, and that diagram is made as nearly ideal as practicable. In the solution of the problem thus set by themselves, these designers have succeeded wonderfully; and this, with their careful provision against internal heat-wastes and against excessive engine-friction, accounts for their rare success in these engine-trials.

But there still remain two important questions undecided:

(1) Are these comparisons fair, as being representative of the best work that each type of engine can perform; and does it follow that the study of the performance of each throughout a wide range of load-variation will prove that these conclusions may be accepted as general and as completely settling the relative standing of these machines.

(2) Assuming it to prove to be true that the orthodox system of designing the multiple-cylinder engine, as illustrated by the refined practice of Leavitt and of Reynolds, of Sulzer and of Corliss, and as taught in the text books and treatises on the steam engine from a more purely scientific standpoint is right, it is always correct, as judged from the point of view of the purchaser and user of the engine, who counts success by the relation of quantity of work performed to the dollar expended, and not with reference, otherwise than incidentally, to the weight of steam or of fuel demanded per I. HP. in the unit of time?

The first of these questions can only be answered after it has become possible to produce a "curve of efficiency" on which may be read the relation of cost to performance throughout the full range, at least, of usual variation of working load, and for each of the machines to be compared. The second must be answered by a study of the costs of power-production, with each reduced to the measure of the efficiency of the dollar in each case.

The following pages present an account of such an investigation as is above outlined, in which the compound,

*Abstract of a paper presented at the New York meeting of the American Society of Mechanical Engineers.

†Director of Sibley College, Cornell University, Ithaca, N.Y.

the triple, and the intermediate type of engine are compared experimentally, by constructing representatives of each type, by various combinations of the elements of the largest of the triple-expansion experimental engines of the Sibley College laboratories. A compound engine was produced by the combination of the high and intermediate cylinders, in which ordinary proportions were illustrated; a second compound was produced by combination of the high and the low pressure cylinders, in which the peculiarity of greatly exaggerated cylinder-ratio was introduced; and the third combination was that of the three cylinders in normal working, and representative of the standard proportions of the ordinary triple-expansion engine. With each arrangement a series of trials was made from the results of which it became practicable to produce the form of efficiency curve which was sought as the solution of the problem to be attacked.

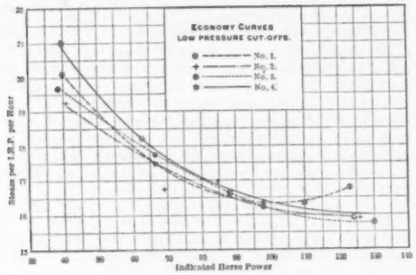


Fig. 1.—Consumption of Steam of a "7 to 1" Compound Engine at Various Loads.

The general dimensions of the engines employed in this investigation are as below:

General Dimensions of Engines.

	Pressures— High.	Inter.	Low.
Diameter of cylinder, ins.	9	16	24
Length of stroke, ins.	36	36	36
Clearance: Head, %.....	7.74	8.79	9.5
Crank, %	7.45	8.89	9.2
Flywheels, diameter, ft.	10	10	10
Weight, lbs. 6,934		6,938	6,935
Steam-port dimensions, ins....	⅝ × 12	1 × 20	1⅝ × 28
Exhaust-port dimensions, ins. .	1¼ × 12	1⅝ × 20	2¼ × 28
Diameter of piston rod, ins. ..	2 5-16	2 5-16	2 5-16

The experiments with the cylinder ratio of 7 to 1 were planned in advance, with great care, and all tests are indicated alphabetically; tests A to E, E to I, I to M, and M to Q being four groups, and all the tests in each of these groups having the same low-pressure cut-off. The groups are arranged so that these cut-offs increase in value, the A to E group containing the tests at the shortest cut-offs and the M to Q group at the longest. The tests in each group are also arranged according to indicated horse-power, which increases with the later letters of the alphabet. The data given here are the averages of the general data and of the principal results.—(We omit the tables.—Ed.)

The economy curves in Fig. 1 show the variations in steam consumption for variations in the indicated power

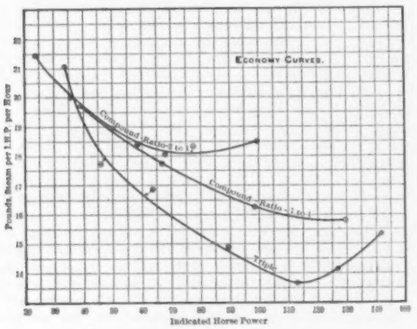


Fig. 2.—Comparative Indicated Economy of Three Engines of Different Types at Various Loads.

for each of the four cut-offs. In No. 1 there is no uncertainty about the maximum point in the curve. Nos. 2 and 3 do not show a distinct maximum; but, from their horizontal drift at the heaviest loads, it would appear that these loads were very near those of maximum economy for those cut-offs. The direction of the line at the end of the economy curve for No. 4 would seem to indicate that the point of maximum efficiency for that curve had not been reached.

A comparison of results with those obtained on the 3-to-1 compound and triple-expansion engines may now be made:

The following data are from experiments made by H. K. Spencer in 1895 on the Sibley experimental engine, and will serve as a basis of comparison of the results just summarized.

The first set of data was taken from the engine while running with the high-pressure and intermediate cylinders compounded, giving a cylinder ratio of a little over 3 to 1. The second lot of data are from the same engine, with all three cylinders in use. In both cases everything was jacketed except the low-pressure cylinders, thus giving approximately the same conditions that existed in the test, here first described, of the compound engine with a cylinder ratio of 7 to 1.

In the proportion and distribution of the receiver volume, the engine during the 3-to-1 compound and triple expansion tests had an advantage. With the 7-to-1 cylinder ratio the engine had an abnormally large receiver volume, and, in the passage between the receivers, the steam was sent through a considerable length of piping which condensed some steam by radiation.

Curves were plotted from the result of these three sets of experiments thus:

Fig. 2 shows the variation of the steam consumption per I. HP., with the increase in load, for the three prescribed sets of conditions. The curves in this figure leave no room for doubt in regard to the relative economy of the three engines. At about 37 HP. the steam consumption in each case is about the same. The curves then diverge, the 3-to-1 compound reaching a minimum steam consumption, at 75 HP., of 18 lbs. The minimum points on the other curves, owing to their larger low-pressure cylinder volume, lie further along, and are 15.8 lbs. for the 7-to-1 compound, and 13.7 lbs. for the triple-expansion engine. We have thus a gain of 2.2 lbs. of steam per I. HP. per hour of the 7-to-1 over the 3-to-1 compound, and a gain over the former by the triple-expansion engine of 2.1 lbs. of steam per I. HP. per hour.

Fig. 3 shows the variation in steam for dynamometric horse-power, with varying load for three cases. It will be noticed that the curves approach each other much more nearly than in the last figure. At the minimum the triple-engine curve exhibits best economy, but it falls off very rapidly, and at 75 HP. shows a greater steam sonsumption than either of the others.

The 7-to-1 curve also crosses the 3-to-1 curve a little below this point. The reason for this is probably the friction of the extra bearings and the weight of the intermediate valve rods, which the construction of the engine made it impossible to avoid for the tests on the 7-to-1 compound. Otherwise there are about the same number of working parts as in the 3-to-1 compound, and there should be very nearly the same per cent. loss by friction.

The minimum points in these curves are 18.9 for the 3-to-1, 18.1 for the 7-to-1, and 17.1 for the triple-expansion, showing a gain on the triple over the curves of Fig. 4 of 1 lb. of steam by the 7-to-1 compound, and a little over 2 lbs. by the 3-to-1 compound.

Fig. 4 shows the variation in the steam used per I. HP. per hour, with the ratio of expansion for the three cases. In the 3-to-1 compound and the triple the most economical ratios are apparent—about 12 for the 3-to-1 compound and 21 for the triple. Assuming the most economical expansion in any one cylinder for a continuous expansion line to be 3, this would make, in the case of the 3-to-1 compound, a total expansion of 9, showing that in the above case there was comparatively little expansion in the receiver. In the case of the triple the division of the expansion ratio is taken from the most economical card, which is as follows: 2.7 in the high pressuse cylinder, 3.15 in the intermediate, and 2.16 in the low-pressure cylinder, making a total of 18.5 as the expansion ratio, which makes the expansion line practically continuous.

In the 7-to-1 compound the best ratio of expansion is beyond the limits of the curve, but would apparently be in the neighborhood of 17. The distribution of the expansion, however, at the most economical point obtained was 2.7 in the high-pressure cylinder; 2.21 in the low-pressure cylinder, leaving 2.85 as the expansion ratio in the receiver. This division is very nearly the same as in the triple-expansion engine, the receiver taking the place of the intermediate cylinder.

The following table shows the conditions during the most efficient periods of test of the three systems:

Comparison of the Most Economical Trials.

	Triple.	7-to-1 compound.	3-to-1 compound.
Boiler gage	119.1	115	117.5
Revolutions per minute	84.95	87.65	85.52
Vacuum in ins. of mercury..	24.3	22.84	22.7
Condensed steam in lbs. 1,205		1,753.7	1,030
Total jacket-water	335.4	316.7	190.97
Total steam used 1,540.3		2,070.4	1,221.2
Total I. HP.	112.65	129.97	67.7
Distribution of work between cylinders, h. p. = 1. { i. c. = 1; l. p. c. = 1. }		1.29	.635
Mechanical efficiency	84.1	86.6	90
Steam per I. HP. per hour ..	13.68	15.8	18.03
Number of expansions.....	22	18.89	15.45
Steam, I. HP. corrected to a vacuum 24.3 ins. mercury	13.68	15.1	17.3

It will be noticed that in the triple-expansion tests both the vacuum and the boiler pressure are better than in either of the others. Between the most economical test of the triple and the most economical test of the 7-to-1 compound, there is a difference of 1½ ins. of mercury in the vaccum, and of 4 lbs. in the boiler pressure. The column showing the three tests reduced to a common back pressure was obtained by increasing or diminishing the mean effective pressure in the low-pressure cylinder of each by the amount each varied in back pressure from that of the required mean. In this case the mean was taken as the back pressure in the triple-expansion test. This correction brings the triple and 7-to-1 compound nearer together, but we shall still have a difference in steam consumption of 1.48 lbs. of steam per HP. per hour between the triple and the 7-to-1 compound, and a difference of 2.1 lbs. between the latter and the compound with the 3-to-1 ratio of cylinder volumes.

In conclusion, these comparisons, after making all allowances, show economy in favor of the triple, when compared to the 7-to-1 compound, of over 1 lb. of steam per HP. per hour, and a larger gain by the latter when compared to the compound engine of 3-to-1 ratio. The bearing of these results, however, on the relative merits of the three types, is a matter which experiment on one engine

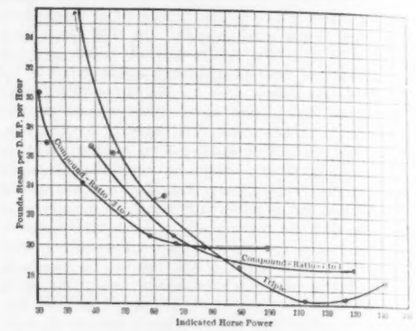


Fig. 3.—Comparative Actual Economy of Three Engines of Different Types at Various Loads.

and under one set of conditions cannot definitely determine. As tests have been made of the triple-expansion engine under all systems of jacketing, there is no room for improvement in this direction. In the 7-to-1 compound, however, a change in the jackets, and even more probably a change in the size and distribution of the receiver volumes, might reduce, if not nearly bridge over, the gap which at present separates it, so far as steam-consumption is concerned, from the triple-expansion engine.

In looking over the water account of both the triple-expansion and the 7-to-1 compound, we find that all the water used by the latter, in excess of the former, passed through the cylinder, and that there is no appreciable difference in the jacket waste in either case. This indicates that the waste is internal, and due to either an extra loss by cylinder-condensation, to a greater clearance loss, or to a loss coming of incomplete expansion of the steam. That the greatest waste is due to incomplete expansion in the high-pressure cylinder, and that there is a slight gain in the cylinder volume, are both made evident by theory and are clearly indicated on the diagram showing the superposed cards of the engines.

The comparative amount of cylinder condensation in the two engines, and the manner in which this condensation is affected by the drop in pressure between the cylinders, is

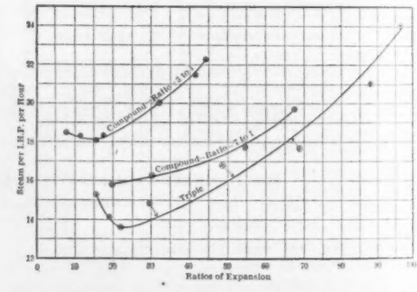


Fig. 4.—Comparative Indicated Economy of Three Engines of Different Types at Various Expansion Ratios.

a matter on which there has been considerable doubt and on which these tests seem to throw some valuable light. (This question is discussed at length in the paper.—Ed.)

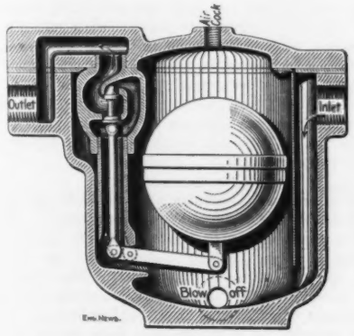
When the practical uses of the 7-to-1 compound are considered, although at [illegible] a constant load, under loads widely varying, such as exists in an electric-power plant, the flatness of the economy curve would seem to indicate that it would more than hold its own. In a comparison of the 7-to-1 with the 3-to-1 compound, all efficiencies seem to favor the larger cylinder ratio. Whether 7-to-1 is the most economical ratio, or whether the most economical cylinder proportion lies at some intermediate point, is beyond the scope of this series of tests to determine. The best cylinder-ratio probably varies somewhat with the work for which the engine is intended, and in an exact determination of the best proportions for maximum economy there remains a large field for experimental investigation.

In studying the preceding figures, it must be carefully kept in mind that the real comparison is by delivered, rather than indicated power, and that the final basis of comparison must, in all cases, be the financial one. It is further to be noted that the curves here given as efficiency curves cover a much larger range of expansion than is either usual or economical in the ordinary commercial conditions of the market; the important and interesting data are those appurtenant to the lower values of the ratio of expansion in this series of engine trials.

The superior quality of steam in the high-pressure cylinder of the 7-to-1 compound engine, due, as it would seem, to the peculiar conditions affecting that machine, would indicate that the process of change of quality was the following: The exceptional drop at exhaust causes a correspondingly exceptionally complete discharge of the charge of mixed water and steam, unusually complete drying of the cylinder walls by re-evaporation, and such promptness of action that comparatively little heat is rejected from the dry cylinder wall during the exhaust period. This results in corresponding reduction of the heat-exchange waste during the succeeding induction period, and this, in turn, means some economy of heat, steam, and fuel, notwithstanding the fact of an exaggerated range of temperature and of pressure in the high-pressure cylinder, circumstances tending to increase wastes.

AN AUTOMATIC STEAM TRAP WITH CONTINUOUS DISCHARGE.

We illustrate herewith a new steam trap which has recently been put on the market by The Reliance Gauge Co., of Cleveland, O. The construction is clearly shown in the sectional view. The Reliance solderless float is used which is guaranteed not to collapse or to leak under high steam pressure. The discharging valve is of the balanced poppet type and is placed at the top of the trap, near the outlet, out of the way of both grit and sediment. In operation the water entering the inlet fills the trap up to the middle of the float, and any additional water causes the float to rise and open the valve, which discharges continuously as long as there is any further inflow. The advantage of the continuous discharge is that it enables a trap of small size to discharge a very



Vertical Section of Automatic Steam Trap. The Reliance Gauge Co., Cleveland, O., Makers.

great amount of water. The valve being balanced, the operation is uniform no matter what the pressure of the steam. The valves and all internal parts being attached to the cap, it can be taken apart without disturbing the piping. As the inlet and outlet are on the same level, it can easily be inserted in a line of piping. A water gage is provided for, which is useful when it is desired to know whether the trap is operating properly, but it is not a necessary part of the trap. Four sizes are regularly made, with inlets and outlets ¾, 1, 1¼ and 2 ins. diameter.

DUSTLESS BUILDINGS.*

By C. J. Woodbury, M. Am. Soc. M. E.**

The increased height of office buildings rendered possible, by what Otis Tufts patented as the vertical railway, while bringing to their occupants relief from the noise of the streets, and affording comfort by extending above the fly belt, which is as well defined as the snow line on a high mountain, also exposes the occupants to the fine dust which pervades the whole structure and which the other salutary conditions of the building renders more prominent.

The modern method of heating and ventilating such a building is by means of a blast of air drawn down a flue, warmed and forced through the building in such quantities that four times the volume of the building is frequently circulated through the rooms each hour. This method of heating is a more efficient application of radiating surface for heating the air than by direct radiation in rooms; it can be managed with far less expense for attendance, repairs and fuel, and it provides the sanitary requisite of ventilation without cold drafts. But it distributes large amounts of dust through such a building, and in a city using bituminous coal under the average conditions there is a fine carbon dust which is especially obnoxious, impairing drawings, books, delicate mechanism, and whatever may be injured by the shower of fine impalpable dust, which produces black indelible smooches whenever touched. This carbon dust is always an annoyance and at times a serious matter.

The writer undertook to abate the difficulty of dust in a building of nearly 500,000 cu. ft. capacity, through which 26,000 cu. ft. per minute was usually blown, for heating and ventilation. The outside air used for this purpose was drawn down a flue 37 sq. ft. in cross section, and reached a velocity of 700 ft. per minute.

The means taken to remove the foreign substances from the air was by use of cotton cloth filters so arranged that the air should approach the fabric at an acute angle by which the momentum would carry these particles beyond a point where the element of air under consideration would pass through the filter, and the particles of dust would be carried by the place, and striking the cloth at a lesser angle, tend to glance off and be carried to the bottom of the filter, rather than to clog the interstices in the fabric. The area of the filters being larger than that of the flue, the rate of filtration was immensely slower than the velocity of the air down the flue.

The means by which this was accomplished were very simple. A timber frame, divided by partitions into fine rectangular openings, was placed at the top of the flue, and under each opening was placed a bag whose top was attached to a light wood frame slightly larger than the opening, making a tight fit, so that the air entering the flue must pass downwards into these bags which were over 30 ft. in height. An arrangement of guides, ropes and pulleys enabled the bags to be raised and lowered by a person at the bottom of the flue. The bottoms of the bags were made open, and closed with a drawing string, and hoops kept the lower portion distended. An arrangement of lines extending along the sides from end to end facilitated turning inside out and back again when they were being cleaned. The whole of the mechanical arrangement is fully described in U. S. patent No. 580,772.

These bags were square at the top, where their combined area equalled that of the flue, but soon diminished to a cylindrical section, occupying about 40% of the space, thus affording ample clearance for the exit of the air passing through the fabric. The area of the flue was 3¾% of that of the bags, and while the air passed down the flue at a velocity of 700 ft. per minute, it passed through the fabric at 26 ft. per minute.

From half a peck to a peck per month of fine dust was gathered from the bags. The efficiency of the device was tested by placing freshly-painted boards at the bottom of the flue before the installation of the apparatus, and then giving another coat of paint after the apparatus was in service. In the first instance the fresh paint collected fine dust until it resembled fine sand-paper, and in the second the paint dried with a smooth surface. In several of the offices split laps of absorbent cotton were placed in various parts of the building before and after the bags were in service, and one set was covered with fine particles and the other was free. The change was not a notable one at first, owing to the large amount of dust in the flues, but much of this was removed by running the blower at a very high rate of speed, and afterwards removing the registers and washing them and the flues as far as could be reached.

The device has been solely under the care and management of the men employed on the engine and boilers, and has served its purpose in rendering a building free from dust caused by the ventilating system.

*A paper presented at the New York meeting of the American Society of Mechanical Engineers.

**Assistant Engineer American Bell Telephone Co., 125 Milk St., Boston, Mass.

THE DOCK OF THE CHICAGO, ST. PAUL, MINNEAPOLIS & OMAHA RY., AT SUPERIOR, WIS.

A dock 150 ft. wide and 1,704½ ft. long was built on Allouez Bay, at Superior, Wis., in 1895, by the Chicago, St. Paul, Minneapolis & Omaha Railway Co. There was also built on the dock a warehouse 80 × 1,500 ft. The object of the dock

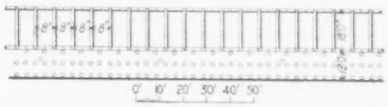


Fig. 1.—Partial Plan of Dock at Allouez Bay, Superior, Wis., for the Chicago, St. Paul, Minneapolis & Omaha Ry.

and warehouse was to give the company an outlet by boat to Buffalo for Minneapolis flour. The company has docks in Duluth, also, but the distance to the lake at that point is ten miles greater than to Superior. Through the courtesy of Mr. Chas. W. Johnson, Chief Engineer of the above railway, we are enabled to describe the construction of the dock, as follows:

The design of the dock is shown by the illustrations, Fig. 1 being a partial plan and Fig. 2 showing a partial cross-section, partial elevation and some details. The dock consists, first, of piling on the outside, supporting a platform; inside of this is crib-work filled with sand. The piling and crib-work together are 30 ft. wide at each side of the dock, the remaining 90 ft. being filled in with sand.

The cribs are sunk 22 ft. below the water line. The slip is dredged to give 20 ft. of water, the depth at the start having been but 6 ft. The material removed by the dredges was used to fill in the dock. White pine, sawed on the line of the railway, was used for the crib. The 3 × 12-in. vertical pieces between the cross-timbers of the crib were not used on the first docks constructed

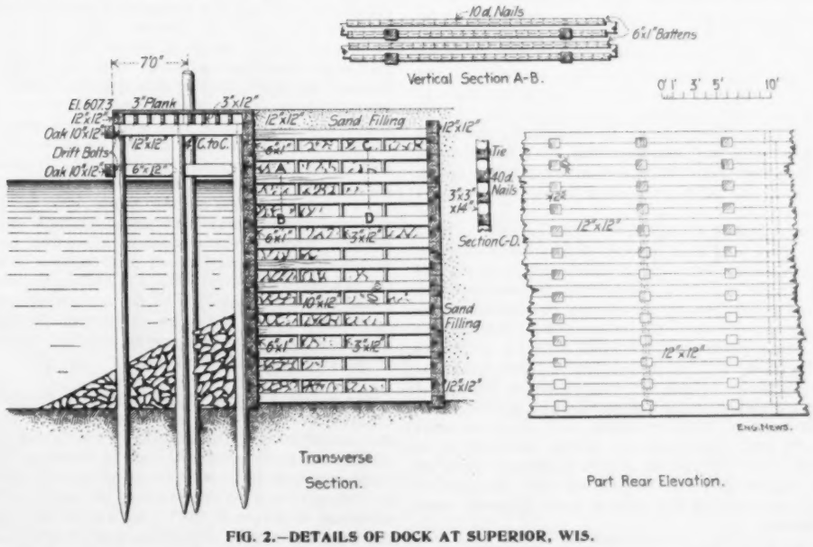


FIG. 2.—DETAILS OF DOCK AT SUPERIOR, WIS.

by the company, but were afterwards adopted to prevent breakage of the cross-pieces.

A pile bridge was constructed as an approach to the dock at a cost of about $160,000, not including freight on the material. This will be filled in later.

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ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page 8. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

The strike of the British engineers, or machinists, as they would be called in this country, has been for months the topic which has engrossed the attention of manufacturers in Great Britain to the exclusion of almost every other subject. This strike, with the lockout by the employers which has accompanied it, has reached proportions such as hardly any other labor disturbance of modern times has assumed.

A conference between the leaders of both sides was held last week; but the terms offered by the employers were such that, although they are to be submitted to a ballot of the men for acceptance, press dispatches state that they will in all probability be rejected. Lack of space forbids our entering upon a discussion of the questions at issue, and we can only say that the employers propose to run their own works without dictation from the unions, employ as many apprentices and piece-workers as they choose, and set a man to tend as many machines as they see fit. These conditions, of course, are all opposed by the trade unions, who not only demand that the present rules of the union shall be retained in union shops, but that the day's work shall be reduced to eight hours.

What makes the question most serious to both employers and men is that so large a proportion of England's industry is dependent upon its export trade, in which competition is international. If the conditions of production in British workshops become such that they cannot compete in price and quality with those of America, Germany or Belgium, a large proportion of them must unquestionably be closed. On the other hand, the hours of labor in British workshops appear to be such as to give the workmen just cause of complaint, and the employers might well afford to make some concessions in this quarter if some of the present absurd restrictions upon the use of machinery which the unions have imposed were abolished.

Probably the most interesting of the papers read at the recent meeting of the American Society of Mechanical Engineers was that by Dr. R. H. Thurston on "Multiple-Cylinder Steam Engines—Effects of Variation of Proportions and Variable Loads." We give an abstract of this paper on another page of this issue, but we explain here that the leading feature of the paper is the demonstration, by a series of tests made at Sibley College, that the Rockwood type of compound engine, in which the cylinders have a ratio of areas of 7 to 1 is more economical throughout a wide range of loads than an ordinary compound with a ratio of 3 to 1. A few years ago, when the Rockwood type of engine was first brought to notice, it was objected to by Dr. Thurston, as well as by many others, on a priori grounds. In fact, the opinion was almost universal that the low steam consumption then reported as the results of tests of the Rockwood engine was due to some especially favorable conditions other than the unusual ratio of cylinder volumes. Dr. Thurston's paper now shows that in the case of an experimental triple expansion engine, whose most economical load was about 115 brake HP., the omission of the second cylinder, thereby converting the engine into a two-cylinder engine with a ratio of 7 to 1, resulted in giving a lower steam consumption for all loads below 85 brake HP. than even the triple expansion engine, and a lower steam consumption than a compound engine with ratios of 3 to 1, made by omitting the high pressure cylinder of the triple expansion engine, for all loads above 72 brake HP. For loads below 72 brake HP. the compound with ratio of 3 to 1 was superior in economy to the compound with ratio of 7 to 1, and much superior to the triple. The results of these trials opens up a wide field for future research, and will prove of great interest to students of steam engine economy the world over.

Klondike Mining Companies, which were so numerous a few months ago, are being rapidly decimated. A few which were managed by men of honesty have wound up their affairs and returned the few subscriptions to their stock which were received, but in most cases those who were induced by glowing advertisements to invest their money will not be so fortunate. Our contemporary, "The Engineering and Mining Journal," in a temperate article declares that under present conditions the Klondike is an unsafe field for the investment of capital:

> Moderate amounts of money can no doubt be placed to advantage in the Klondike field by men of good judgment actually on the ground; but the simpletons who invest on the names of directors or otherwise without knowledge because they have caught the Klondike craze, will lose their money. Investments in the shares of most of the Klondike companies whose prospectuses have come to our notice are simply gambling bets, with the chances enormously against the gamblers.

Perhaps the most prominent of the Klondike companies is the "Joseph Ladue Gold Mining & Development Co.," a concern which acquired a reputation through the presence in its directory of Messrs. Chauncey M. Depew, Thos. L. James, H. Walter Webb, Smith M. Weed, Wm. J. Arkell and other well-known men. Our contemporary dissects the prospectus of this concern, which was advertised in the principal newspapers of the country a short time ago, and shows that the claims of the prospectus appear to rest, for the most part, on very shaky foundations. It further shows that Mr. Joseph Ladue, who transfers to the company various mining claims, etc., is to receive for the property transferred about a million dollars, whereas the company, according to its prospectus, is to pay about four million dollars for the same property. What is to become of the other $3,000,000 appears to be a very pertinent question, and one which the officials of the Ladue company, who gave such wide publicity to their prospectus, ought to answer.

The recent hearing of the Interstate Commerce Commission has finally given us in formal shape the arguments of the railways, which are petitioning for an extension of time in which to equip their cars with automatic couplers and air brakes, according to the requirements of the safety appliance law of March 2, 1893. As will be seen from the very full report of the hearing, which is published in another column, the railways bring forward two main reasons why they consider an extension of time warranted. It is pointed out, first, that to equip their cars according to the law means a very heavy extra expense, and they have not been able to earn the money to meet it during the hard times of the past three years. The second reason urged is that if the law is enforced an undeserved hardship will come upon those railways, which have complied with its provisions, if they are prevented from handling the cars of all other roads which have failed to equip them properly. This last reason is plainly a very strong one. As we pointed out in our issue of Sept. 30, if all the unequipped cars were cut out of operation on Jan. 1, 1898, a car famine and interruption to freight movement would surely result which would be a public calamity. There is no doubt but that the Interstate Commerce Commission fully realizes this fact and will give it due regard in its decision.

Since writing the above, press dispatches from Washington announce that the Commission has decided to extend the time at which the law will go into effect until Jan. 1, 1900, or for two years. In an authorized statement given to the press the Commission says:

> While the formal order and statement of facts and reasons constituting causes for such extension have not yet been prepared, it is thought that the extension will not be conditional, and the commission has under consideration the question of requiring quarterly or other periodical reports of progress by each carrier during the two-year period.

This decision, we think, will be, on the whole, satisfactory to all the interests concerned. In asking the Commission to make the extension of time five years the railways were demanding more than they had any reason to expect. Making all the allowance possible for the railways' financial condition, and with a full knowledge that it will take some time to equip 600,000 cars with brakes and couplers as required by law, there was no valid reason for asking for a five-year extension. With reasonable activity half that time should be sufficient for the most backward road to equip its cars without cutting an excessive number out of service at any one time, and, at the same time, bring the annual expenditure within reasonable limits. On the other hand, to reduce the time to one year might have caused a degree of inconvenience which was not fully warranted.

In view of the fact long ago shown in this journal, that complete equipment with brakes and couplers will make possible large economies in operation, whereas at present comparatively little benefit is derived from the millions of dollars already spent for brakes and couplers, it is really for the financial interest of the railways to use every means possible to hasten the equipment of their rolling stock.

In our personal column of Nov 25 it was stated that Dr. Elon A. Hooker was engineer in charge of the construction of "the Hydraulic Laboratory, Sibley College, Cornell University." As most of our readers are aware, however, Sibley College is the College of Mechanical Engineering of Cornell University, while the splendid hydraulic laboratory referred to is an integral part of the College of Civil Engineering of the same institution. This laboratory, designed by Professor Fuertes, was described by him at the Quebec Convention of the American Society of Civil Engineers.

THE USE OF GEARED LOCOMOTIVES.

A demand for locomotives of considerable tractive power for use on lumber and mining railways having exceptionally rough and light track, heavy grades and sharp curves irregularly laid out, has led to the introduction of geared locomotives, in which the power is transmitted by shafts and gearing to two or more independent trucks. The advantages of locomotives of this class are their great tractive power, due to the fact that the entire weight is utilized for traction and that the gearing is designed to effect a speed reduction between the cylinders and the driving wheels; their ability to pass over sharp curves by reason of the fact that each truck turns as independently of the others as the trucks of a freight car, and their adaptability to roughly-laid track laid with light rails, on account of the weight being distributed over a considerable number of wheels, spaced far apart.

Within the past 15 or 20 years there has been a great development in engines of this type. A large number of the engines have been built for railways of the character noted above, and some

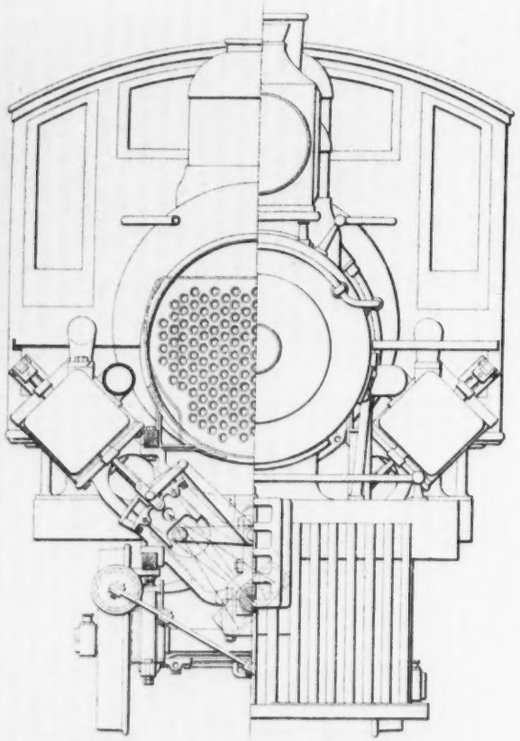


FIG. 2. SECTIONAL END ELEVATION.

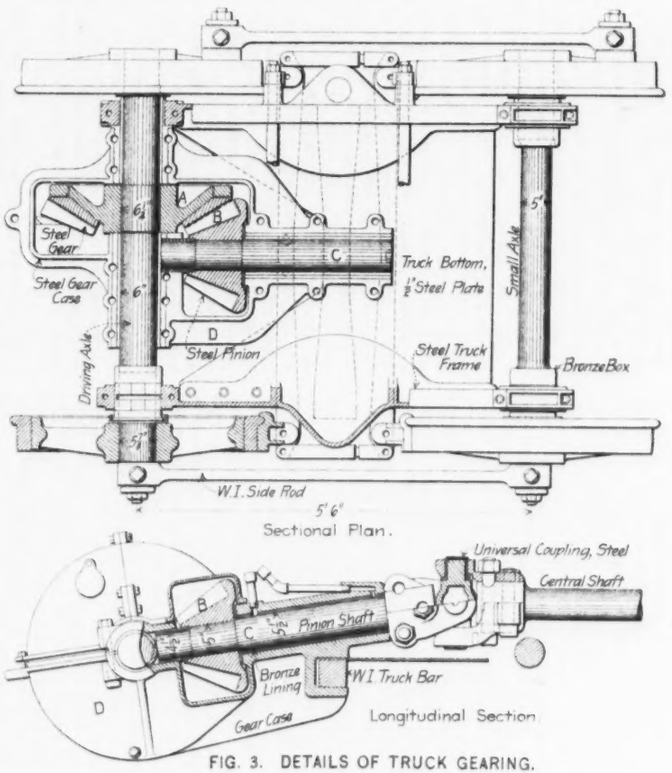


FIG. 3. DETAILS OF TRUCK GEARING.

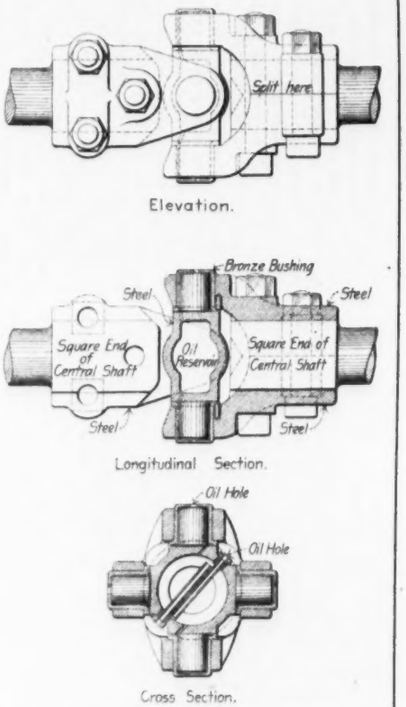


FIG. 4 UNIVERSAL COUPLINGS, ENLARGED.

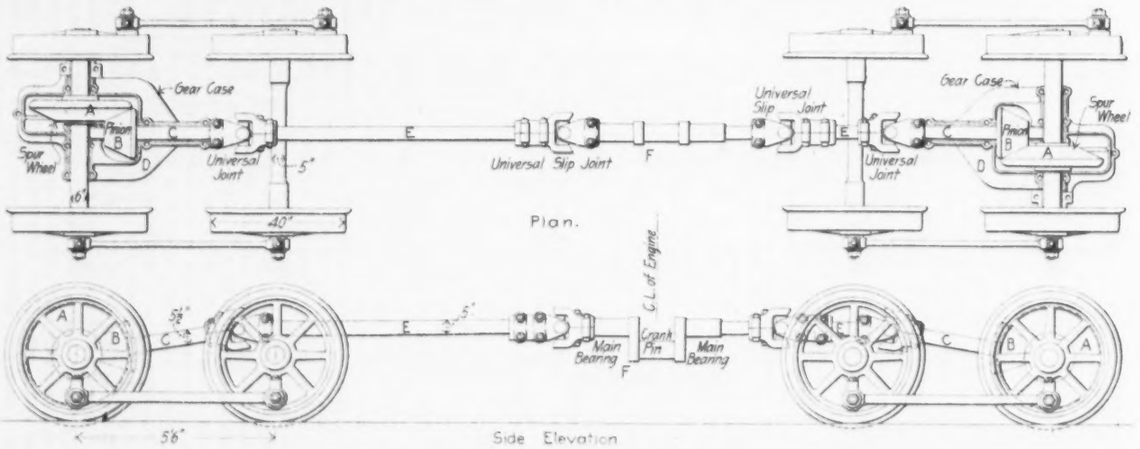


FIG. 1. GENERAL ARRANGEMENT OF GEARING.

THE HEISLER GEARED LOCOMOTIVE.

Designed by Chas. L. Heisler, M. E.

Built by the Stearns Mfg. Co., Erie, Pa.

CHAS. HART & SONS, LITH., 38 VESEY ST., N. Y.

have also been built for lines of a somewhat higher character, including some mountain lines built on the adhesion system for excursion or general traffic.

Geared locomotives may be divided into two general classes, according to the arrangement of their gearing, as follows: First, engines having outside shafts with bevel pinions gearing with bevel spur wheels secured to the outside faces of the driving wheels; second, engines having inside shafts, and gearing mounted on the truck axles. The well-known Shay locomotive, which was one of the earliest of the modern-geared locomotives, represents the first class, and a great number of these engines have been built. In these engines, as our readers will remember, there are two or three vertical inverted cylinders placed at one side of the boiler or firebox, the boiler being set with its center line nearly a foot to one side of the center line of the track, so as to make room for the cylinders. The connecting rods drive a horizontal longitudinal crank shaft, which is connected by universal couplings and intermediate or floating shafts, with shafts carried in bearings attached to the truck frames. These latter shafts have bevel pinions gearing with bevel spur wheels bolted to the outer faces of the driving wheels. Such engines have from four to six axles (in two or three swiveling trucks), and each axle is driven by gearing. As the power is applied, however, to only one end of each axle, it necessarily imposes severe twisting strains on the axles and truck frames, with consequent wear of journals, brasses and pedestals, and only a well-designed and heavily-built truck frame will maintain the axles in alinement. The cranks and gearing are likely to strike obstructions at the side of the track or to injure persons standing near the engine, especially as the gearing is generally exposed. Sand and dirt are apt to get into the gearing, and the grease used to lubricate the gears frequently drips on the rails and causes slipping of the wheels. The swiveling of all the trucks in passing round sharp curves causes the shaft connections to take very wide angles, and much power is thus lost in the couplings, which are liable to be broken in this way. The telescopic slip in the couplings also is often excessive. All this tends to pull the truck frame out of square, and thus to give the axles a position oblique to the track, causing a grinding of the wheel flanges and rails. Furthermore, the vertical motion of the axles due to wear of the brasses and irregularities of the track, as well as the lateral motion due to the wear of the brasses and pedestals, affects the gearing, so that the teeth of the wheels may be too much or too little in mesh. The attachment of the cylinders to the boiler or firebox is also likely to cause serious strains and vibration in those parts.

Nevertheless, in spite of these various objections, the side-shaft engines have done good work and are quite extensively used. Particulars of the Shay side-shaft locomotives have been given in our issues of April 26, 1890, and July 19, 1894. Some of these engines for the Buffalo & Susquehanna Ry. and the Montana Union Ry. weigh as much as 80 tons.

To avoid some of the main defects in the first (or side-shaft) class, the second (or central-shaft) class was devised, having the main driving shaft under the boiler on the longitudinal center line of the engine. This shaft drives the truck axles by means of ordinary bevel gearing or by skew gearing (with the teeth radiating from a point outside the gear center). The longitudinal shaft must of course be made flexible to allow for the swiveling motion of the trucks. The middle piece, forming the crank shaft, is carried in bearings secured to the main frame, and thus maintains its alinement in relation to the frame and the cylinders. On each truck is a piece of shafting carrying the driving pinions, and this is carried in bearings secured to the truck frames, or suspended from the axles. This maintains the gearing in mesh, and also maintains the shaft in alinement in relation to the truck frame. Intermediate or floating shafts connect the crank shaft with the truck shafts by means of universal couplings and slip joints. The Gilbert and Climax engines are examples of this type. The earlier styles of these engines had vertical cylinders, but later they were made with inclined cylinders, those of the former being included in a plane transverse to the track, and those of the latter inclined in a plane parallel with the track. In many engines of this class, great difficulty attended the replacement of knuckle shaft connections, while renewals of the gears could only be made after first removing the driving wheels from the axle. When it is remembered that most geared engines are built cheaply and are subjected to the roughest kind of usage, on roads remote from well-equipped machine shops, it will be seen that the question of facility and expense of repairs and renewals is very important. The gearing, too, is as likely to become crusted with dirt and dust as is the gearing of the side-shaft engines, and is somewhat more difficult to lubricate.

The Climax engines, of this center-shaft type (described in another column), are built with the cylinders in approximately the same position as on an ordinary locomotive, the connecting rods driving a transverse shaft which drives the main longitudinal shaft by bevel gearing. This in turn drives each axle by bevel or skew gearing. Usually there is but one set of gearing between the crank shaft and the longitudinal shaft, but in one form of the Climax engine the crank shaft drives another transverse shaft by spur gearing and this drives the longitudinal shaft by bevel or skew gearing. This is still further complicated by placing two sets of spur gear on the crank-shaft, one for high speed and the other for slow speed. There are thus seven sets of gearing on the engine, six of which are necessary for its working. This introduces such an amount of gearing as almost certainly to interfere with the efficiency of the engine as compared with the power absorbed, besides entailing extra expense for maintenance and repairs. In one design of center-shaft engine, the cylinders and motion are under the cab, and thus difficult of access for inspection and oiling, while one of the universal couplings is enclosed and almost surrounded by the ashpan. In another design, these particullar defects were avoided by the introduction of an extra pair of gears, with shafts and bearings, making five pair of skewed gears on the engine.

In the Heisler geared locomotive, of the center-shaft type (also described in another column), several of the objections above referred to have been eliminated. An important advantage is that the amount of gearing is kept as small as possible, only one pair of gear wheels being required for each truck. There is no gearing between the crank-shaft and intermediate shaft, all the shafts being connected directly by universal couplings, while coupling rods are used to drive the axles not driven by gearing. As the gears are entirely enclosed and run in an oil chamber they will naturally work more easily, and be more durable than exposed gears whose teeth are liable to be covered with sand and dirt. The gears are mounted on the middle of the axles so that there will be a minimum twisting strain on the truck frame and a minimum slip of the universal couplings of the shafts as the trucks swivel in passing around the curves. A specially advantageous feature in the arrangement of the gearing is that it is so mounted as permanently to maintain the pinion and spur wheel in their proper position relative to one another, regardless of any motion of the axle in relation to the truck frame, thus reducing the liability of loss of power by slip of the gearing. Each pinion has its shaft journaled in a frame suspended by sleeve bearings from the axle on which is the spur wheel. Both pinion and spur wheel are thus carried by one axle, and the gearing is supported quite independently of the truck frames. Each spur wheel is built up of two sections secured to a hub forced upon the axle by hydraulic pressure, and these sections can readily be removed and renewed by the tools ordinarily carried upon the locomotive.

We have not alluded thus far to one of the most important features of a geared locomotive, namely its cheapness. To most of those who use geared locomotives small first cost is one of the chiefest considerations. One reason why such a machine can be built more cheaply than a regular locomotive, is that the cylinders and boiler are considerably smaller. Another reason is the rough workmanship that is permissible, and even in some parts desirable for a locomotive that is to be knocked about in the woods and handled and kept in repair by mechanics not of the highest grade. But while efficiency or fuel economy may generally be a secondary consideration in the design of a geared locomotive, any cheapening in the construction at the expense of strength is an economy which will cost the purchaser dear. Probably the chief fault which has been found with geared locomotives is their frequent breakdowns. It is encouraging to note that in the more recent designs great attention seems to have been paid to securing strength in the working parts and to facilitate repairs, when they become necessary.

It is sometimes claimed that regular direct-acting locomotives can be built to haul as heavy a load as geared engines, and that they will do more satisfactory service. Those who make such claims, however, overlook the peculiar advantage of the geared locomotive in the distribution of its weight, all of which is utilized for traction over a long and flexible wheel-base. For example, the 78-ton geared locomotives of the Buffalo & Susquehanna Ry. have the weight (all available for adhesion), distributed over a total wheelbase of 41 ft. 6 ins. by means of three rigid wheelbases (of the driving trucks) of 4 ft. 8 ins. A 50-ton engine for the Colorado & Northern Ry. has its weight distributed over a total wheelbase of 42 ft., with three trucks of 3 ft. 8 ins. to 4 ft. 8 ins. wheelbase. Now a 40-ton consolidation engine, with 35 tons on the driving wheels, has a total wheelbase of about 18 ft. 6 ins., and a rigid wheelbase of about 12 ft. 10 ins., while a 76-ton mogul engine has 68 tons concentrated on a driving wheelbase of 14 ft. With all due allowance for blind tires on some of the driving wheels of these direct-acting engines it is evident that it will be difficult for them to pass curves as sharp as those easily passed by geared engines with their flexible wheelbase. A 30-ton geared engine with two four-wheel driving trucks on the Mill Valley & Mount Tamalpais Ry., in California, passes numerous curves of 70 to 75 ft. radius. For mogul and consolidation engines with about the same weight available for adhesion on a wheelbase of 12 ft. the sharpest curves advisable for regular service are of 165 to 180 ft. radius.

Most of the geared locomotives weighing 50 tons and more have three driving trucks. Two are under the main frame (one under the boiler and the other under the tank and coal bunker behind the cab), and the third is under an auxiliary tank or tender. It is very evident that an engine with a load of 78 tons distributed at twelve points on 42 ft. of track may be safely operated on a much lighter rail than an engine with 68 tons distributed at six or eight points on 12 to 14 ft. of track. Railways of the class which make use of geared locomotives are and will be very generally built with very light rails, and for these, particularly when combined with sharp curves, the geared engine appears to be specially adapted.

It may be said that the advantages of the geared locomotive in the respects just noted might be obtained by driving each truck by independent cylinders, as in the Fairlie, Mallet, Hunt and other engines; but this would involve extra cylinders and motion and also some system of flexible steam connections. The steam joint is well known to have been one of the weak points of the Fairlie engines used on the Denver & Rio Grande R. R. in its narrow gage days. It would also be possible, of course, to transmit the motion from one pair of cylinders on the frame to the truck wheels by means of rocking levers and rods, as in the Johnstone engine. The difficulty of properly maintaining the numerous bearings, particularly the ball joints or universal joints necessary to allow for the swiveling of the trucks, would, however, make such a system practically inadmissible for a poor track with irregular curves.

In conclusion, therefore, it appears to us that the improvement of the geared locomotive is a matter well worth more general attention. It is quite within the bounds of possibility that the use of speed reduction gearing between the motor and the driving wheel may be found advantageous on railways of a somewhat higher type than those built by the lumberman or the contractor. It is worth bearing in mind that practically all the

electric cars in operation to-day in this country have single reduction gearing between the motor and the driving axle; and here, as in some other matters, it is possible that the railway engineer may profitably study the experience gained in electric railway work.

LETTERS TO THE EDITOR.

Concerning North River Transit.

Sir: Your editorial, in the issue of Nov. 25, on North River transit, says that "Unfortunately the promoters of the projected North River bridges have failed to appreciate the fact that it is the suburban traffic, and practically that alone, on which their structures must depend for income." As far as the North River Bridge Co. is concerned, the statement is incorrect. A perusal of the published Congressional reports, and of my articles on the North River bridge problem, in the "Engineering Magazine" of November, 1893, and November, 1895, would have shown you that not only has that company not failed to appreciate the fact mentioned, but credit should have been given it for having, from the beginning, fully recognized and stated that condition of traffic, and for having been the first to point out the subordinate nature of the freight and through traffic. That the company has been guided by it in the location of its bridge, as far as the local conditions permitted it, is to the investigator self-evident; that it has also been guided by it in the location of the approaches to the shopping region and to the business region of lower New York (below Canal Street) requires at present no public discussion.

Your editorial further alleges that the late Geo. B. Roberts, President of the Pennsylvania R. R., said: "When the people of New York get over their sentiment against a pier in the North River they will get a bridge across it, but they never will before." Having known the views of Mr. Roberts on the bridge question, I feel justified in doubting very much that he ever said anything of the kind. He was not a bridge engineer, and did not pretend to pass on the question of pier or no pier in the river, in view of the fact, known to him, that borings had shown the rock in the middle of the river, opposite Cortlandt Street, over 265 ft. deep, and further up, over 250 ft. deep, and that pier foundations of that depth presented such unprecedented difficulties as to make the building of any bridge at all a very costly undertaking.

The North River at New York presents the most formidable engineering and financial difficulties, for either bridging or tunneling it, of any known navigable water at a large city, a fact not mentioned, appreciated or investigated in your editorial. A certain intensity of traffic is required to justify the great cost of such undertakings. Whether or not that traffic has been reached over the North River I see no good reason, nor have I authority, for publicly discussing, or furnishing the latest data for, at this time. Gustav Lindenthal.

New York, Dec. 1, 1897.

The Durability of Tropical Timber Used in Engineering Work in the Tropics.

Sir: So little is known about the durability of tropical timber used in a tropical climate that I believe a few facts, gathered from my own observation and experience, will be interesting to engineers engaged in work within the limits of the torrid zone.

Native timber was used for ties and bridges in the construction of nine miles of railway for the Caribbean Manganese Co., starting at Nombre de Dios, Department of Panama, Republic of Colombia. But in the selection of this timber we were handicapped by the fact that hardly any native timber had been previously used thereabouts for engineering work. The only other railway in the Department was the Panama Railway, and upon that road lignum vitae ties, from the valley of the Magdalene River, had been almost exclusively employed for years. These ties were said to last in first-class condition for 15 years or more, and some are claimed to have been in the track for 30 years before removal. But their cost was prohibitive for our company, as this cost ranged from $1.30 to $1.80 in gold each.

For this reason we decided to use the timber found in the neighborhood of the projected railway, and to depend, in part, upon the experience of the natives with the timber employed as posts and mudsills in their huts. Rejecting all that had been found to decay rapidly under the use mentioned, we made a selection of ties that cost, on the average, delivered, about 55 cts. silver, or the equivalent of 25 cts., at that time, in American currency.

I have already noted some of these facts in a paper upon "The Construction of a Mountain Railway in Colombia," presented before the American Society of Civil Engineers at the annual convention in 1896. But at that convention a sufficient time had not elapsed to determine the average durability of the timber employed. Last summer, however, I had occasion to go over the line, and as most of the track had been laid for more than 2½ years, I had an excellent opportunity to study the effect of time upon the ties and wooden trestles. Through the courtesy of Mr. E. G. Williams, the present Superintendent of the company, I was enabled to note the renewals made to the time of my visit.

An examination revealed the general fact that a few of the native woods, used as ties, rotted within one year; a larger number decayed in the second year, and in the third year the only woods that did not show any signs of decay were the Nispero, or Hymenae Courbaril, and the Cutarro, which is a variety of Guayacan, or Lignum Vitae. The ties that had decayed in two years were chiefly Aceite Maria, Carbonero, Harino, Sigua and Quira, to give their local names. These same woods, used as stringers and piles, lasted better; during the third year only a few of the piles had to be cut off above the water line or above the ground; the parts under water or under ground remained in good condition. In the 2,500 lin. ft. of trestling a few of the stringers had been renewed at the time of examination. While it should be said that many of the stringers and piles were made of Nispero, or the durable wood above named, many others of them were of the woods that had rapidly decayed as ties.

For some of the stringers we employed Georgia pine; and although this outlasted most of the native timbers, it was found to be inferior in these qualities to Nispero and Cutarro. Creosoting, when properly done, adds considerably to the life of pine in the tropics; but financial reasons prevented the use of treated timber in the railway here referred to. Yours truly,

E. J. Chibas,
Assoc. M. Am. Soc. C. E.

144 West 43d St., New York city, Nov. 30, 1897.

Formulas for Tractive Effort in Train Acceleration Tests.

Sir: In comparing the results given in the article on "Recent Tests of Acceleration and Braking" (Eng. News, Oct. 14, page 250) with some of my own calculations, I find that one of your formulas which I have been using is upside down. Tractive effort per ton should equal $\frac{w\,v^2}{2\,g\,l}$ + friction. As it may mislead the unwary, I would advise correction. Yours truly,

Theodore Cooper.

35 Broadway, N. Y., Oct. 19, 1897.

(A proof of the above was submitted to Mr. W. B. Potter, Engineer Ry. Dept. General Electric Co., and we append his reply.—Ed.)

Sir: In the table of tests of the acceleration of passenger trains with various motors, published on p. 250 of your issue of Oct. 14, the formula for tractive effort per ton should read:

$$\text{Tractive effort per ton} = \frac{\text{Distance run in feet}}{(\text{seconds})^2 \times .00804} + 10 \text{ to } 20 \text{ lbs. friction, or}$$

Traction effort per ton = rate of acceleration (in miles per hour) × 91.5 + friction.

The formula to which your correspondent calls attention is correct, with the exception that .0084 should read .00804, as above stated. This formula will give precisely the same results as the formula mentioned by your correspondent, my formula being based on miles per hour, however, while his considers feet per second. The difference between the formulae is best shown by calculating a given case by each of them.

Selecting, for example, a body weighing 100 lbs., moving a distance of 80 ft. in 4 seconds, the tractive effort for a uniformly increasing velocity, with friction neglected, would be, according to Mr. Cooper's formula

$$\frac{w\,v^2}{2\,g\,l} = \frac{100 \times (40)^2}{2 \times 31.16 \times 80} = 31.1 \text{ lbs.}$$

This formula of Mr. Cooper's takes into consideration the final velocity, which is not necessary for purpose of ascertaining simply the tractive effort required to accelerate over a given distance in a given time. It is, of course, a factor advisable to know and one easily ascertained, but in the tests which I made for acceleration the distance covered and the time are the two factors first ascertained, and for that reason I selected the formula for tractive effort as given in the table, and in which only the distance and time appear. To show how this formula was derived, I will start with the fundamental proportion:

$$\text{Seconds} \times 32.16 : \text{Final Velocity} :: \text{Weight} : \text{Force}$$
$$t \times g : v :: w : f$$

In this proportion the unit of velocity is 1 ft. The unit of weight is 1 lb. The unit of force, or tractive effort, is 1 lb.

$$f = \frac{\text{Final Velocity} \times \text{Weight}}{(\text{Seconds}) \times 32.16}$$

$$\text{Final Velocity} = \frac{2 \times \text{Distance}}{\text{Seconds}}$$

Substituting above,

$$f = \frac{2 \times \text{Distance} \times \text{Weight}}{(\text{Seconds})^2 \times 32.16} = 2\,\frac{s\,w}{t^2\,g}$$

Substituting values,

$$f = \frac{2 \times 80 \times 100}{(4)^2 \times 32.16} = 31.1 \text{ lbs.}$$

The formula that I have used in the table is similar to the one last given above, with this exception: that the unit of weight is 2,000 lbs., or one ton.

Substituting 2,000 w in place of w, as above,

$$f \text{ per ton} = \frac{2 \times \text{Distance} \times 2{,}000\,w}{(\text{Seconds})^2 \times 32.16} = \frac{\text{Distance}}{(\text{Seconds})^2 \times .00804}$$

Substituting values in example,

$$f \text{ per ton} = \frac{80 \text{ ft.}}{(4)^2 \times .00804} = 622 \text{ lbs.}$$

Actual f for 100 lbs. (.05 tons) = 622 × .05 = 31.1 lbs.

The result, therefore, is the same in each case. The difference in the formulas and the misunderstanding arising from the fact that I have used as units tons instead of pounds and miles per hour instead of feet per second.

I trust that I have made my reasons plain, but these formulae of acceleration are susceptible of so many modifications and re-arrangements that unless one has in mind the particular reasons for using a certain formula they sometimes seems obscure.

I would add, with reference to the tests for rapid acceleration made at the Schenectady works of the General Electric Co., and described in your issue of Oct. 14, that they were made for the special information of Mr. John Lundie, Consulting Engineer to the Illinois Central R. R. Co., in connection with his investigation of the applicability of electric traction to its suburban train service.

Very truly, W. B. Potter.

Schenectady, N. Y., Nov. 16, 1897.

Notes and Queries.

S. asks: "Is there any general rule for estimating the value of plant and good-will of a long established engineer and surveyor in active practice? I have heard it stated that the net income for a year was an approximate estimate. Is that generally accepted as a fair valuation, or how can such a valuation be arrived at?"

We know of no possible general rule for such estimates. The reputation and good-will of any such business will be worth much in one case and little in another, and might be worth more to one purchaser than to another.

Apropos of the discussion as to whether the Loschwitz bridge is a cantilever or suspension structure, in our issue of Dec. 2, Mr. David Molitor writes that, with the fuller information respecting the structure given by Mr. Reissner, he agrees that it is a cantilever structure. We were unaware that the structure exerted no horizontal stress upon its supports until the receipt of Mr. Reissner's letter, and believe that in view of this fact engineers will generally agree that it is actually of the cantilever type, and likewise that it well deserves its title of "The Blue Wonder."

Xn is informed that anonymous letters cannot be noticed by the editors.

THE HEARING REGARDING THE SAFETY APPLIANCE LAW BEFORE THE INTERSTATE COMMERCE COMMISSION.

The hearing of the railways, which had petitioned the Interstate Commerce Commission for an extension of time within which to comply with the law enacted in 1893 requiring all railways carrying on interstate commerce to equip engines and cars with automatic couplers, air-brakes, etc., was opened Dec. 1, at 10.15 a. m., at Washington, D. C. The small hall of the commission was filled with the representatives or attorneys of almost every railway of prominence in the country, and with delegates representing several of the principal railway labor organizations. From questions sent out by the commission some time previous to the hearing it appeared that railways owning 1,060,704 cars had petitioned for a general extension of time. These companies were divided into four classes, according to the percentage of their cars equipped, and a hearing was first given to the roads which had already completed their equipment according to law, or would be able to do so by Jan. 1.

Speaking for the Boston & Albany, Mr. Samuel Hoar stated that fully 75% of the cars hauled over their lines were foreign cars, most of them unequipped. It would be unfair to prevent the Boston & Albany, which had fully complied with the law, from hauling these cars. Should the law be put in operation literally, the entire business of the country would be blocked, and a vast amount of injury would be done to the public, as well as the railways. Chairman Morrison asked what assurance the commission would have that railways would make greater efforts to observe the law in the future than in the past should the time be extended.

Mr. John K. Cowen, as chairman of a committee representing railways owning some 600,000 freight cars, said that since 44½% of the freight cars were supplied with automatic couplers, and 36½% with air brakes, it was evident the railroads had made honest efforts to comply with the law of 1893, especially when the financial depression following so closely upon its passage was considered. The interstate commerce of this country is so interwoven that the business of transportation is practically a unit, and if the law were to be enforced on Jan. 1 the whole commerce

of the country would be interrupted. Mr. Cowen argued that Congress recognized the tentative nature of the act and displayed its wisdom by giving the commission the power to suspend its operation from time to time when sufficient cause for such suspension or extension was shown. He urged that railway managers were not justified in expending about $100 per car to equip old rolling stock which in a very brief time must be withdrawn from service..

While a few roads might be found which had endeavored to evade the law, the large majority had honestly endeavored to meet its requirements. With the experience of the past and the brighter business prospects ahead, an extension of five years with the condition inserted that in each year one-fifth of the cars at present unequipped must be supplied with safety appliances seemed to him fair to all parties concerned.

To complete the equipment with safety devices, between $40,000,000 and $50,000,000 must be expended by the railroads of the country. Should the five-year extension be granted, the expenditure of this large sum could be distributed over several years and could therefore be met without reducing wages or interfering with commerce.

Mr. P. H. Morrissey, speaking for the Brotherhood of Railroad Trainmen, the Brotherhood of Locomotive Engineers, the Brotherhood of Locomotive Firemen, the Order of Railway Conductors, and the Order of Railway Telegraphers, said that the question was not solely a commercial one; the lives of the men engaged in railway operation, as well as the danger to passengers, demanded that no such unreasonable extension as five years be granted. During the period allowed by Congress for the adoption of these safety appliances 2,000 men had been killed each year, and between 20,000 and 25,000 had been injured, fully 60% of these casualties were attributable to the two evils the law was designed to correct. There would be no justice in treating all railways alike, for some companies had made every effort to comply with the law, while others had done nothing. In reply to the suggestion of a reduction in wages, Mr. Morrissey remarked that that question would be considered by the employees when the occasion arose. He said that the operatives were willing to make concessions, and did not ask for anything unreasonable, and that they considered a general extension of a year as ample.

Ex-Senator Butler, on behalf of the Mobile & Ohio R. R., and Mr. Loomis, of the New York Central, also spoke on the intent of the law and the reason an extension should be granted. Mr. G. W. Rhodes, Superintendent of Motive Power of the Chicago, Burlington & Quincy R.R., argued that an extension of time was necessary in order that proper safety appliances might be selected.

In concluding the morning session, estimates of the time needed to complete their equipment were asked for of the roads at present most nearly complying with the law. The estimates varied from one year to five years, a good proportion, however, being well within the latter figure.

Immediately after the recess, Mr. Julius Rosendale, of Philadelphia, presented several letters from prominent clergymen and a petition from certain labor organizations, which asked the commission to refuse any extension of time. Representatives of railway companies followed, all favoring a general extension of time to all railway companies.

Mr. Samuel Gompers, president of the American Federation of Labor, appealed to the commission to refuse an extension to any road which had declared dividends during the term provided by Congress, instead of devoting the money to obeying the law.

Mr. Clark, of the Chicago & Great Western, in reply to Commissioner Prouty's questions, stated that the earnings of his road were over $4,000,000 last year, but that the company could not devote $60,000 to equipping its 3,000 unequipped cars next year for the reason that it would not be economy to do so.

The commission then called for the roads having 25% to 50% of their cars equipped, and one after another their representatives stated the reasons why their companies were delinquent. These reasons were practically a repetition of those already noted, including the financial depression, receiverships, yellow fever, necessary repairs to tracks, bridges, etc., shops unable to handle cars fast enough, a doubt as to the proper coupler, lack of uniformity, etc.

Commissioner Knapp asked if a five-year extension with the 20% clause were granted, and there should be a default at the end of the first year, whether there would not be the same problem presented to the commission as existed at present?

In reply to this, Mr. Cowen said that an extension for such a short time as a year, or even two years, was an invitation for railways to default because it was absolutely certain that many roads could not comply within that [illegible]

At this point a somewhat lively passage-at-arms occurred between Mr. Cowen and Mr. Morrissey. The former stated that Mr. Morrissey did not in any way represent the Baltimore & Ohio employees. Mr. Morrissey replied that at the Toronto convention, at which 85% of the Baltimore & Ohio employees were represented, it had been decided to ask the commission to refuse any extension, but in response to Mr. Morrissey's request this point was left to the discretion of the delegate. He also remarked that he represented the employees of the Baltimore & Ohio quite as much as Mr. Cowen did its stockholders. In neither case had the individuals been consulted directly.

At the Thursday forenoon session, Mr. Wm. Brown, general counsel for the Chisago & Alton, argued that his company had a right to pay dividends rather than put safety appliances on its rolling stock, and declared that stockholders were entitled to a return on their investment to the same degree that wage earners were entitled to their pay. He repeated the argument that a reasonable extension would comply with the law, and not exceed the power granted the commission, while a refusal would punish those roads already equipped, as well as those that had made no effort to comply with the law. In reply, Chairman Morrison said that the law would be enforced to protect life and limb, and not for the purpose of punishing anyone.

Ex-Congressman Payson reported that 55% of the Southern Pacific R. R.'s freight cars were equipped with safety devices, and renewed the request for a five-year extension.

After the recess Mr. M. H. Smith, president of the Louisville & Nashville R. R., presented several reasons why his road had not made a better showing. In the course of his remarks, he stated that it was possible, and to him seemed probable, that the American people would at some time demand the confiscation and government operation of railroads. Two petitions were presented to show that an extension would be satisfactory to the employees and shippers on the Louisville & Nashville lines. Mr. Thomas, president of the Nashville, Chattanooga & St. Louis R. R., stated that he considered it only fair that those investing money should have some return in the same way that those investing labor should be compensated, and that after making necessary repairs and improvements to track and bridges and paying labor, interest and dividends, there was not enough money remaining in the treasury of his road to comply with the law of 1893.

Several times during the hearing "line cars," or cars which are owned by private concerns, came up for consideration. It was developed that several of the line car companies had been recently building new cars, which were not equipped as required by law. On this point, the general opinion, as shown by several speakers, was that the term "common carriers" in section 3 of the act, as it now stood, also the clause prohibiting railways hauling unequipped cars, included all cars whether owned by railways or private companies.

Since the above was put in type the Interstate Commerce Commission has rendered its decision. Briefly, it grants a general extension of two years, requiring at the same time that quarterly progress reports be submitted by all delinquent roads. This is a compromise between the requests of the railway employees and the average extension asked for by the railways.

THE NEW DELAWARE RIVER BULKHEAD AT PHILADELPHIA, PA.

On Nov. 27, 1896, the City Councils of Philadelphia authorized the construction of a new bulkhead on the easterly line of Delaware Avenue, between Vine and South Streets in that city. There is available for this improvement about $2,150,000, of which $1,500,000 was appropriated by the Councils, and $650,000 comes from the Girard Fund. The estimated property damages amount to $750,000, leaving $1,400,000 for the construction of the proposed bulkhead and for the new city piers at Arch and Chestnut Streets.

The work now contemplated includes the widening of Delaware Ave. by the construction of the bulkhead, and the extension and partial reconstruction of sewers cut by the proposed work. From the plans prepared by Mr. G. S. Webster, Chief Engineer of the Bureau of Surveys, and from the specifications issued with them, the method of work may be described as follows: There are two general plans for the bulkhead, known as the concrete and timber sections. The latter section is to be used at certain localities back of the bulkhead line and existing piers. For these timber sections piles will be driven, 5 ft. c. to c., braced, capped and diagonally floored at about mean low water. Four sets of diagonal piles, driven at an angle of 30° to the vertical, will brace the front of this timber portion, and about 35 ft. from the face will be driven a line of 10 × 12-in. sheet piling. On the river face of this timber foundation will be built a concrete wall, 6 ft. wide on the base, 3 ft. 6 ins. wide on top, and with a face batter of 1 ft. on 1 in. Filling upon the floor provided and back of the concrete wall will complete this portion of the work.

The general concrete section requires a more detailed description. The soft bottom is first dredged down to hard mud along the line of the bulkhead, and the excavation is refilled with coarse gravel to the line of the average river bottom, the fill being 16 ft. wide on top, and with side slopes of 1 on 1½. Into this fill piles will be driven, as shown in the illustration, and sawed off about 10 ft. below low water line, for the four front rows of piles. Back of these front piles are three rows of anchor piles, spaced 10 and 8 ft. apart, and with the tops cut off and clamped above mean low water. From each pile in the center row extend two diagonal piles, and from the cap of these piles and anchored in the base block of concrete is a 2-in. tie-rod; these rods are spaced 8 ft. apart. Upon the heads of the four front rows of piles is then lowered the first block of concrete, and sunk immediately before it is a concrete mattress made by enclosing cement mortar in a burlap bag. The dimensions of the concrete blocks, forming the first and second course of the wall, and their relative form and position are shown in the section given. These blocks weigh about 30 tons each, and are provided with 12-in. chain holes to facilitate handling, and a 2½ ft. square projection on top for joining and setting them. These two courses will bring the bulkhead to about the level of mean low tide, and they will support the concrete wall built upon them, which will extend to 2.5 ft. above City Datum, or 4 ft. 9 ins. above mean high tide. In this concrete wall will be built drainage outlets at short intervals. A 10×12 in. white oak ordnance timber finishes the upper wall, and along the line provision is made for electric light poles.

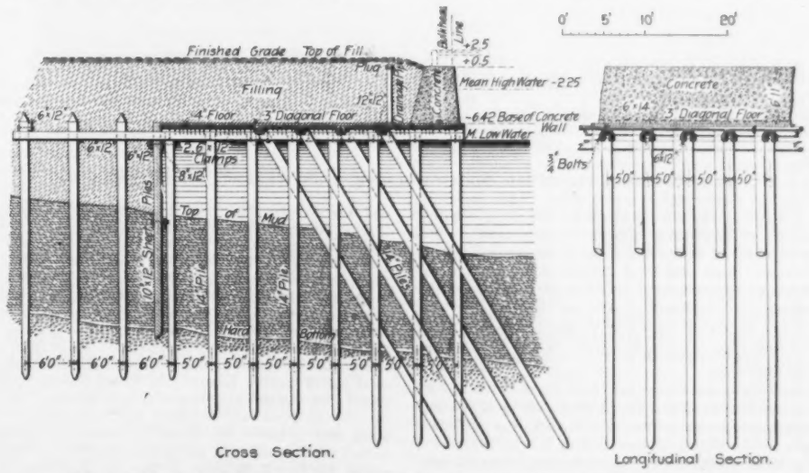


FIG. 1. TIMBER BULKHEAD, DELAWARE RIVER IMPROVEMENT, PHILADELPHIA, PA.

The concrete used is to be made of one part Portland cement, three parts coarse sand or gravel and six parts of broken stone, crushed to pass through a 2-in. ring and screened so as to reject all particles less than ¼ in. diameter. This concrete, when made, is to be kept in motion until permanently deposited in layers not exceeding 9 ins. in thickness; it is to be compacted by 25 lb.

rammers until a film of water appears on the surface. The filling of any form must be continuous in making the blocks. The concrete wall is to be built in wooden forms, with the river face, for a thickness of 5 ins., made of concrete composed of one part Portland cement, three parts coarse sand or gravel and five parts of stone crushed to pass through a ½-in. ring. This face work is to be built up in layers of the same thickness and at the same time that the main wall is constructed. Between the smooth outer form and the fine concrete a granolithic mixture is to be carefully worked in by experienced men, so as to leave a smooth face on the river side when the form is removed. This mixture will be composed of two parts of Portland cement and three parts of "granolithic" broken stone, with water enough to make a stiff mortar. Granolithic concrete will also be used to finish the top of the wall. Above low-water mark vertical joints will be left for expansion located about 72 ft. apart, and made by finishing the concrete on one side of the joint, and after the concrete has set, forming the adjacent section by first placing tarpaulin against the completed section.

The cement mattress referred to is formed and used as follows: This mattress is made of burlap, or bagging, of convenient width and of a sufficient length to cover the piles under a block. A mortar is then made of one part Portland cement and three parts of approved sand, and this is spread 3 ins. thick on the bagging attached to a wooden frame. Immediately before a foundation block is lowered into place this frame and its mattress is lowered onto the heads of the piles as sawed off.

The filling permitted behind the walls is specified as good loam, clean ashes, gravel, broken rock, or other approved material. All old cribs must be removed above certain elevations and the material taken away. The face of the gravel fill under the walls must be protected by stone riprap, and the widened avenue will be paved with granite blocks on the completion of the bulkhead and filling.

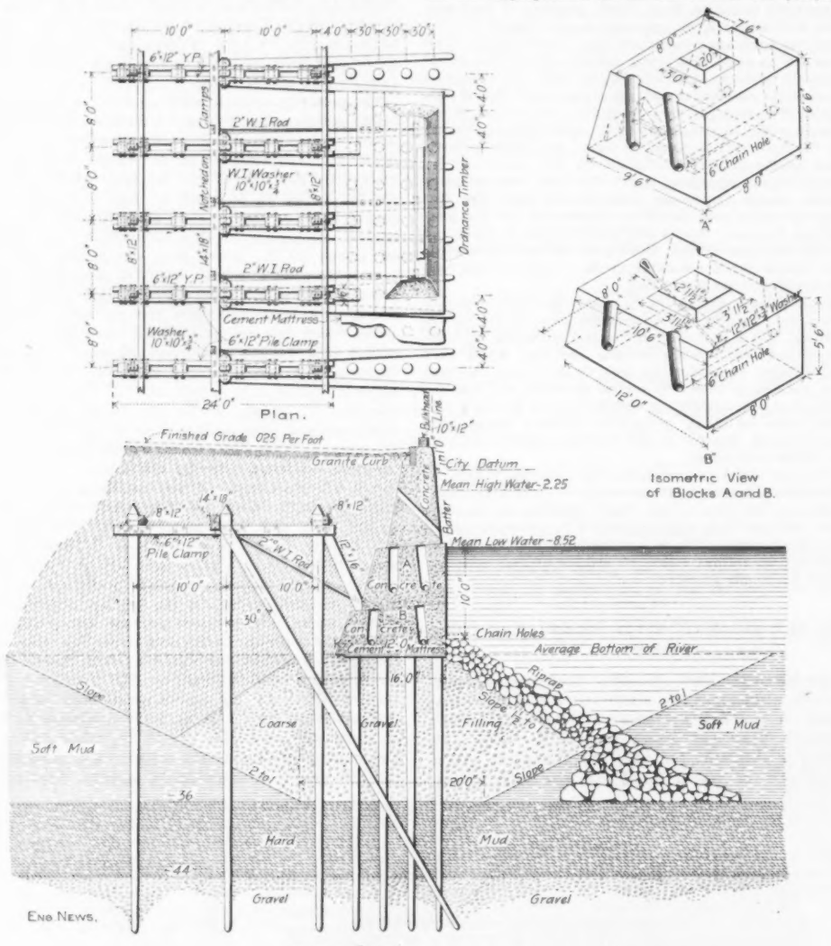


FIG. 2.—CONCRETE BULKHEAD, DELAWARE RIVER IMPROVEMENT, PHILADELPHIA, PA.

and was made in 1890. This money was all used in building the 4½-mile section at the western end. In 1892 a second appropriation of $500,000 was made and was used in completing the section at the western end and on the first 8-mile section at the eastern end. The third appropriation of $190,000 was made in 1894, and was used in the work at the eastern end and in surveying the principal feeder. In 1896, the appropriation amounted to only $45,000. This appropriation, however, placed the work under the continuing contract system, and as it has also been placed on the sundry civil bill the construction is sure to be continued, although it may be slow. In 1897 the appropriation was $175,000, and this money is now being used in excavating the second section of eight miles at the eastern end. At the present session of Congress strong efforts will be made to have the appropriation increased to an amount which will allow the work to be pushed without delay for the want of money. The Illinois & Mississippi Canal work is under the charge of Maj. W. L. Marshall, U. S. Engineer Corps, who is located at Chicago, Ill., and it was fully described in our issue of Feb. 14, 1895.

THE NEW YORK STATE CANAL SEASON, for 1897, was a poor one, as there was a loss of nearly 12,000,000 bushels in grain shipments, reported at Buffalo, as compared with 1896. The actual figures were 23,848,621, for 1897; 35,868,906 bushels in 1896; 20,064,613 bushels in 1895, and 48,418,622 bushels in 1894. The year 1896 was an exceptionally bad one, and comparison with the other years show a very unfavorable condition for last year. This falling off is ascribed by boatmen to railway competition. The receipts of rail grain at New York, from May 1 to Dec. 6, 1897, were 98,806,625 bushels out of a total of 120,964,731 bushels, while in the same period in 1896 the rail receipts were 64,369,975 bushels out of a total of 96,846,937 bushels. In 1897 the canal was also handicapped by a delay of two weeks in opening and has been obstructed somewhat by improvement work in progress.

THE TONNAGE OF THE LEADING STEAMSHIP lines of the world is given in the following list published by "Fairplay," of London, compiled from the latest reports of the Bureau Veritas and Lloyd's Register. From this list it appears that the Hamburg-American line is the largest shipping company in the world:

Companies.	Tonnage—Gross.	Net.
British—		
P. & O. Steam Navigation Co. (London)	283,140	161,836
British India Steam Nvgtn. Co. (London)	251,429	162,482
T. Wilson, Sons & Co. (Hull)	159,793	102,450
Pacific Steam Navgtn. Co. (Liverpool)	128,336	77,774
Cunard Steamship Co., Ltd. (Liverpool)	119,471	65,011
Ismay, Imrie & Co., White Star Line (L'pool)	114,290	68,264
German—		
Hamburg-American Line (Hamburg)	286,945	174,990
North German Lloyd (Bremen)	265,613	152,126
Hamburg-South American Steam Navigation Co. (Hamburg)	100,646	65,422
Hansa Steamship Co. (Bremen)	84,867	54,446
French—		
Messageries Maritimes Co. (Marseilles)	229,837	114,000
Compagnie Generale Transatlantique (Paris)	166,701	72,113
Italian—		
Navagazione Generale Italiana (Rome)	171,041	105,598
Austrian—		
Austrian Lloyd (Trieste)	146,560	87,800
Spanish—		
Compania Transatlantica (Barcelona)	121,161	78,702
Japanese—		
Nippon Yusen Kabushiki Kwaisha (Tokio)	161,698	101,383

THE BROOKLYN DRY DOCK REPAIRS PROGRESS about as follows: The coffer dam across the entrance is completed. This dam is placed about 40 ft. in front of the gate, and is 156 ft. long and 35 ft. wide. It is made up of three bulkheads of sheet piling, arched in plan for the two outer ones, with the minor bulkhead straight. The 12 ft. space between the outer bulkheads is filled with clay, and this wall is strengthened by an earthen embankment outside and a rock fill within. The piles used in the outer line are 54 ft. long and 12 × 14 ins.; the inner row of piles is made of 12 × 12-in. sticks of Georgia pine. The dock has already been pumped out and a large leak has been found under the apron leading to the gate seat. The apron itself was covered with 3 ft. of mud, and there was, at first, some difficulty in removing all the water and exactly locating the leak. Men are now at work removing the altars at the head of the dock, preparatory to replacing them with new altars, braces and piling over a space about 100 × 15 ft.

THE GOVERNMENT ARMOR PLANT is estimated to cost as follows by the board appointed for this purpose:

Name of Department.	Estimates
Open hearth department	$541,918
Forging and cementing shop	1,558,237
Bending and tempering shop	446,038
Machine shop	600,651
Erecting shop	94,461
Boiler shop	119,574
Power plant	134,658
Blacksmith shop	32,411
Locomotive shop	7,219
Carpenter shop	8,686
Office building	15,000
Chemical laboratory	25,000
Physical laboratory	33,000
Railroad track and equipment	86,642
Latrines	11,112
Water supply, sewerage, etc	33,298
Total	$3,747,912

As this estimate is made without exact knowledge of the site, and local conditions, no freight charges are included and the foundation estimates only cover o stable footing in good hard pan or gravel. But 5% has been allowed for erecting and engineering expenses, and the board believes that another 5% would cover all possible contingencies of foundation. This plant would have a capacity of 6,000 tons per annum of nickel steel, face hardened, reforged armor, and it includes plant for the production of open-hearth steel ingots. As such a government plant would not be connected with other branches of the steel industry, says the board, its successful and economic administration would depend upon a constant demand for an output approaching its full capacity. As the plates must be specially designed for and fitted to ships, this would mean a constant yearly appropriation for ships to be supplied with armor. The economy in armor plate production, sought for by the action of Congress in appointing the board, seems to be a somewhat vanishing quantity, under the existing conditions.

GARBAGE COLLECTION AND DISPOSAL BIDS in Philadelphia were received on Nov. 30 by Mr. Thomas M. Thompson, Director of Public Works. Surprise was

created by the fact that the present contractors, two in number, were very much underbid by two competitors, notwithstanding the fact that the former have disposal plants already built and in operation. The lowest bid for the whole of the five districts into which the city is divided was $210,600, from Mr. Horatio P. Connell, ex-Sheriff of Philadelphia, and the next lowest was $265,000, from Case & Peoples. Each of the present contractors, between whom the city is now divided, put in bids aggregating about $350,000 for the whole city, each bidding the lowest on the districts now held by it. One of the present contractors uses the Arnold system of utilization and the other the Smith crematory. What system the lowest bidder proposes we have not yet learned. The next highest bidder, Case & Peoples, have been experimenting with a large plant in Philadelphia for some time past.

A GARBAGE COMPROMISE IN NEW ORLEANS bids fair to be effected after a conflict of several months between the city and the contractors. On March 15, 1894, a contract was made between the city and the Southern Chemical & Fertilizing Co. for the collection and disposal of the garbage, dead animals, ashes, street sweepings and general house and store refuse of the city for a term of 20 years. The contract provided for the separation of ashes and other refuse from the garbage. The contract price was $120,000 a year for the first five years, $134,000 for the second, $150,000 for the third and $165,000 for the fourth five years, an average of $142,250 per year for the 20 years. The Simonin system of garbage utilization was established, but the disposal works were shut down about Nov. 20, 1895, partly, the contractors have stated, on account of the low prices obtainable for the products, but largely because the citizens would not keep the garbage separate from the other wastes. Finally the company refused to remove mixed garbage and the city installed a collection service, alleging that the contract was broken. The company went into the hands of a receiver, and the receiver appealed to the courts, succeeding in tying up some of the funds of the city pending a final decision of the court. The city council has just approved the terms of a compromise and voted to have an ordinance drawn in accordance therewith. A new contract is proposed, limited to ten years from date of execution, and with a flat rate of $10,000 a month for all services rendered. The city is to pay the company $70,000 for past services, of which about $40,000 is for legal claims during the period in which the city has been removing the garbage. The company agrees to remove mixed garbage, which has been the principal bone of contention. It is said that the company will build a new disposal plant.

THE DISCHARGE OF SEWAGE INTO PARK RIVER by the city and town of New Britain, Conn., has been declared a nuisance by the Board of Health of the City of Hartford, and notice has been served by the board ordering the nuisance abated by June 1, 1898. Mr. Jas. Campbell is President of the Hartford Board of Health, and Mr. G. C. Dunham is City Engineer of New Britain.

THE BENEFICIAL EFFECTS OF WATER-METERS at Richmond, Va., are strikingly shown in a special report recently made by Mr. Chas. E. Bolling, Superintendent of Water-Works. Mr. Bolling placed 263 meters in the lower part of the high service district of the city about a month in advance of beginning to charge meter rates. At the end of a month the meters were read, and consumers having leaky fixtures were notified in order that they might have them repaired before meter rates went into effect. The meters were again read at the end of the second month, and it was found that whereas their total registration the first month was 4,326,611 gallons, it was only 1,171,187 gallons the second month. At meter rates the cost of water consumed the first month would have been 67% greater than that actually charged the people, in accordance with the number of fixtures in use. For the second month the meter charges were 47% less than the old ordinance rates. About 700 meters have been placed and more are to follow. The pressure has increased materially at points where its lowness was previously a matter of complaint.

THE NORTHWEST WATER SUPPLY TUNNEL now under construction at Chicago is the source of the latest charges of fraud made in connection with the municipal affairs of that city. It is stated that the progress and the character of the material have been incorrectly reported, while the work has not been done in accordance with the specifications. Two men have been discharged and the Commissioner of Public Works will have an investigation made of all the work done on the tunnel.

REDUCTIONS OF WATER RATES in Chicago have caused a loss to that city of nearly $500,000 in the past two years, according to the report of a committee appointed by the mayor to investigate alleged frauds in the water department. The reductions were made by the superintendent and other officials (some of whom are under indictment), and some were made on no authority whatever. Mr. McGann, the Commissioner of Public Works, purposes the establishment of a uniform rate for large consumers of water and also the extension of the meter system to check the present reckless waste of water.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

In our last issue we noted the proceedings of the opening session of the annual meeting of the American Society of Mechanical Engineers in New York city. This session was held on Tuesday evening, Nov. 30. The other sessions were held on Wednesday, Thursday and Friday mornings and Thursday evening. On Wednesday evening a reception was held at Sherry's, which was largely attended by the members and their ladies and by many invited guests. The afternoons were left free for the members to enjoy as they saw fit, many of them spending them socially in the Society's rooms. The meeting was the largest ever held by the Society, 609 members and guests being registered as in attendance.

The session on Wednesday morning was occupied chiefly with formal business, including reports of the council, of the treasurer, and of the tellers of election. The latter reported the following officers elected for the ensuing year. For President, Chas. Wallace Hunt, New York city; for Vice-Presidents, to serve two years, John C. Kafer, New York city; David R. Fraser, Chicago; Walter R. Russel, Detroit, Mich; for Managers, to serve three years, James B. Stanwood, Cincinnati, O.; H. H. Suplee, Philadelphia; George Richmond, New York city; for Treasurer, Wm. H. Wiley, New York city. The report of the council showed that the total membership of the Society is 1,823, of which 442 are associates or juniors. Among other matters reported by the council was the fact that the Society has become the owner of Mr. Oberlin Smith's design patent for the oval form of the decimal wire and sheet metal gage, and has, for the sum of $1, granted a license to the Pratt & Whitney Co. to manufacture such gages. It will grant similar licenses, on request, to other firms of good standing. The council also reported that Mr. George Westinghouse, of Pittsburg, had been elected an honorary member, and that Niagara Falls had been chosen as the place of the spring meeting of 1898.

The report of the Treasurer showed cash receipts during the year of $28,309, and expenditures of $28,337, of which latter $1,800 went to purchase bonds of the Society as an investment. The Society now holds $23,400 out of $32,000 of its second mortgage bonds. The Library Association, which owns the building of the Society, reported that its building is valued at $65,000, the first mortgage on it being $33,000, and the second mortgage, held entirely by the Society and by some of its members individually, is $32,000. Its net assets over liabilities, $15,847, are represented by furniture, equipment, books, etc. It is expected that the $8,600 of bonds held by members will become the property of the Society within the next three years.

After the reading of the reports, Mr. C. W. Hunt, the newly elected President, made a few remarks. He was followed by Mr. G. C. Henning, who was the Society's delegate to the International Conference on Standard Tests and Testing Materials, which was held at Stockholm in August. He gave a brief account of the proceedings of the conference, and stated that hereafter its transactions will be published in the English language, as well as in German and French. He stated that the most important paper discussed at the conference was one by Prof. Osmond on micro-metallography as a method of testing. It is intended to form an American section of the international congress on testing.

A motion was passed authorizing the council to appoint a committee of the Mechanical Engineers' Society to confer with the American section of the congress, when it shall be organized, regarding the establishment of uniform specifications and methods of tests for materials of construction.

The draft of the report of the Committee on Boiler Tests was then presented and briefly discussed, and further discussion was postponed until the session of Thursday evening.

The question of uniform sizes of union nuts for pipe couplings and of square heads for bolts was then brought up, and it was shown that no approach to a standard size exists among the different manufacturers of pipe unions. A resolution was passed authorizing the appointment by the council of a committee to confer with committees of the Steam Fitters' and other associations on the subject.

A paper by Mr. F. W. Dean, on "Reduction of Cost of Steam Power from 1870 to 1897," was then presented and discussed. We give an abstract elsewhere in this issue. The author was complimented for his able presentation of the historical part of the subject, and for his contribution of new data on steam engine economy, but his opinions concerning steam boilers were strongly objected to. The leading feature of the discussion was the reading of a long paper by Mr. Allan Stirling, criticising Mr. Dean's statements in favor of the horizontal tubular boiler. He made some good points, but the effect of his discussion was weakened by his evident desire to advertise a particular form of boiler in which he is interested.

The next paper taken up was a short one, entitled

"Boiler Tests; Classification of Data and Plotted Results."

By Wm. Wallace Christie, Paterson, N. J.

The author has selected from various sources the reported results of over 200 boiler tests, and after tabulating them has plotted the results so as to discover, if possible, the relation between the amount of coal burned per square foot of heating surface per hour and the economy as expressed in terms of the equivalent evaporation from and at 212° per lb. of combustible. Whatever relation of cause and effect there may be between these two variables, it does not appear in the paper. For instance, in 37 tests of vertical boilers with anthracite coal both the highest and the lowest economy were obtained with a rate of combustion between 0.3 and 0.4 lbs. of coal per hour per square foot of heating surface, and in 40 tests of vertical boilers with bituminous coal, both the highest and the lowest economy were obtained rate of combustion of between 0.2 and 0.3 lbs. The following is the author's principal conclusion:

The location in the diagrams of most economical performance seems to him to be within a certain area rather than on a particular line; and the writer has tabulated these areas of most economical performance as follows:

Boiler.	Coal.	Between rate of combustion pr sq. ft. of H.S. of	Best at coal per sq. ft. of H.S.	Best at ratio of H.S. to G. S. of
Vertical.....	Anthracite..	0.27 to 0.47	0.3	40 to 52
Vertical.....	Bituminous..	.21 " .29	.21	48 " 63
Horizontal..	Anthracite..	.13 " .51	.35	24 " 94
Horizontal..	Bituminous..	.13 " .54	.315	41 " 68

In the discussion it was pointed out that the paper contributed nothing new to our knowledge of boiler economy, and especially to the question of the relation of rate of evaporation to economy. Mr. Stirling took a hand in this discussion also, and tried to show from Mr. Christie's results that they favored his pet form of boiler, but it cannot be said that he succeeded. When the results of 200 boiler tests made at different times under all sorts of different conditions are thrown together and plotted, and it is found that the highest and the lowest economy in a vertical boiler are obtained at practically the same rate of evaporation, it is surely not possible to draw from that collection of results anything particularly favorable to a vertical boiler.

At the session on Thursday morning the first paper presented was that of Prof. R. C. Carpenter, entitled "Tests of Centrifugal Pump and Calibration of Weir at the Bridgeport Pumping Station, Chicago." We published an abstract of this paper in last week's issue. The discussion related chiefly to weir formulæ, and Prof. Thurston expressed the opinion that in the light of Prof. Carpenter's experiments on a large weir, it appears that Weisbach's formula for weirs should be used instead of the commonly used formula of Francis. Prof. Carpenter's coefficients of flow are considerably higher than the Francis formula would give. One member regretted that the paper did not give more of the history of the famous, though short-lived Courtright "undulating" pump, and Prof. Carpenter promised to remedy the omission in his final revision of the paper.

Purifying Water.

The next paper was entitled "A Water Purifying Plant," by Howard Stillman. This paper was printed in our last issue. A written discussion was presented by Mr. Albert A. Cary, in which he criticised some features of the plant designed by Mr. Stillman. He favors a single precipitating process, using lime water instead of milk of lime, and caustic soda instead of soda ash, as the chemical agents. Mr. E. N. Trump said that the Solvay Process Co., Syracuse, N. Y., had been purifying water containing sulphate of lime for ten years. They had 12,000 HP. boilers. They found soda ash to be the best reagent for the purpose. The Beaume hydrometer was used to control the density of the water in the boiler, due to sulphate of soda in the treated water. When the density reached 3° the boilers were blown down. The nostrums sold in the market for boiler compounds were analyzed, and it was found that nine-tenths of them contained from 75% to 90% of soda ash. It is the cheapest boiler purge, and also chemically the best.

A discussion on the merits of a so-called electric feed-water purifier followed. Mr. S. M. Greene, of Holyoke, Mass., said that after he had tried several kinds of compounds, including soda-ash, crude oil, etc., all of which had failed to keep the tubes from leaking, he had tried the electric purifier, and it proved successful. Mr. C. L. Newcomb, also of Holyoke, said his place was a few hundred feet distant from Mr. Greene's, and he had tried the electric purifier, and it failed. The salesman of the purifier then told him that it had been turned upside down, but reversing it made no improvement. One member then said that the "electric" purifier was one of a class of humbugs that often prove very successful when applied to boilers. When applied they apparently improve the condition of the boiler, but the improvement is due to some other cause than the alleged one, such as more frequent blowing off of the boiler, etc. It was explained that it was not possible for an electric current to be generated inside the boiler by the means described, which consisted in passing the water before it entered the boiler through an enlarged pipe in which there were alternate plates of copper and zinc. If the zinc plates were taken away, or abraded by

the flow of the water, particles of zinc or zinc oxide or salts might be carried into the boiler, where they might cause some chemical reaction on the sulphate of lime precipitated, preventing the formation of a hard scale; but if this were true, the same result could be accomplished by putting plates of zinc in the boiler, as was commonly done in England.

The Rockwood Engine.

The next paper was one by Dr. R. H. Thurston, on "Multiple Cylinder Steam Engines—Effect of Variation in Proportions and Variable Loads." We print an abstract of this most valuable paper in this issue. A long discussion followed the paper. Mr. F. H. Ball criticised it for not more clearly stating the conclusions drawn from the tests it describes. Mr. Rockwood, whose type of engine with cylinder ratios of 7 to 1, was the one treated of in the paper, commended the paper in general, but objected to his engine being called a "mutilated" type. He says it is a type by itself, and the very best type up to date. The general opinion seems to be that Mr. Rockwood's claims for this type of engine, which he has been urging against strong opposition for three or four years, are now substantiated. Prof. H. B. Gale called attention to the fact that nine years ago he had advocated "drop" between the cylinders in compound engines, which is a leading feature of the Rockwood type.

The next paper presented was

Notes on Rating Electric Power Plants Upon the Heat-unit Standard.

By Wm. S. Aldrich, Morgantown, W. Va.

The following is an abstract:

These notes refer to a paper on this subject read by the author before the Hartford meeting (May, 1897).

The earlier reports of the Committee on Data of the National Electric Light Association have been full of instructive information relating to many types of steam-power electric plants. In all of the cases finally reported, their rating has been based on watt-hours per pound of coal. From the several reports of the Committee on Data of the National Electric Light Association, Tables I. and II. have been compiled. An inspection of these will show what little progress has been made during the last four years in such installations.

TABLE I.—Showing Results of Four Years' Progress in the Economic Performance of Steam-Power Electric Plants.

Year.	No. of Stations reported.	Watt-hours per Pound of Coal. Max.	Min.	Av'ge.
1894. . . .	65	208	25	91.7
1895. . . .	24	262	36	128
1896. . . .	81	237	53	108
1897. . . .	14	269.5	98.7	156

In the 1897 report of the committee, Mr. F. R. Low very fully discussed the several sources of loss in the electric power plant, stating the discrepancies would be made up mainly from the following items: (1) Decreased boiler efficiency; (2) lesser normal efficiency of engine; (3) impaired conditions of engines; (4) unfavorable engine load; (5) leakage; (6) condensation; (7) auxiliaries; (8) heating. It has been repeatedly pointed out that the chief differences are those due to the running conditions of electric plants, and not entirely due to sudden and wide variations of load.

In this connection it is important to notice the results of Mr. H. A. Foster's analysis of the tests of 22 different power plants. These included manufacturing establishments, electric light stations, pumping engines, etc. Plants above 200 HP. show a remarkable uniformity in fixed charges; namely, interest on first cost, depreciation, taxes, and insurance. The operating expenses gradually decrease in plants from 200 to 100 HP., above which capacity the operating expenses seem to remain remarkably uniform and quite irrespective of load variations. The large electric stations supplying many smaller industries are scarcely affected by the instantaneous load changes in one or more of these particulars.

The conclusions to be drawn from all of the preceding clearly indicate that the economy of the modern high-duty pumping-engine plant is due to a refinement of design and economic arrangement of the installation that has not yet been reached in the electric power plant.

It is apparent, from a careful study of the last four years' record of the Committee on Data, that some very uneconomical engines have produced remarkable results in point of economy of operation and efficiency of installation. The best of engines may be poorly operated on the one hand, and the whole plant badly arranged on the other hand.

In the discussion which followed the presentation of the author's paper on this subject before the Hartford meeting, as well as in conference with members and other electrical and mechanical engineers, since, it will appear that the following points have been brought out: (We give here only a few of these points.—Ed.)

That the heat-unit, as a basis for such ratings, is both rational and scientific. It is, however, not in consequence the most satisfactory standard for use by builders, contractors, and practical engineers dealing with this class of motive-power machinery; namely, steam engines and dynamos.

That the present extensive and satisfactory use of the heat-unit for steam-pumping installations is as it should be and is all right in that place; but this is no argument for its introduction and use in a similar manner in the rating of steam electric plants.

That the present way of stating the performance of electric power plants, however unsatisfactory, is easily understood by all parties interested. Chief of these, of course, is the capitalist; he can readily comprehend rating based on the coal bill.

That the load factor, after all, has not so much to do with the fuel economy of the plant. Therefore, in the large city and suburban steam-power and electric plants now being installed, there is not the necessity for such strict adherence to economic load factors as in the case of plants with smaller units.

That the watt expresses the activity or rate of the electrical output, in joules per second. In this respect it is analogous to the horse-power rating of mechanical output. Hence, the standard rating should be in kilowatt-hours per 1,000,000 B. T. U. supplied to the steam used in the whole plant.

That the boiler should be in evidence in all cases in which plant performance is mentioned.

That the common rating of performance of pumping plants in foot-pounds per 1,000 pounds steam would be amply sufficient for all purposes of rating electric plants for which the heat-unit basis is advocated. This seems particularly plausible on account of the small variation in the total heat of one pound of steam for quite a wide range of pressures now used in modern electric plants. It is claimed that this is within the usual allowable errors of observation and measurements in power-plant tests, and that there is not enough difference to warrant the trouble required to obtain the performance reduced to a B. T. U. standard.

The paper brought out no discussion, the author being absent. It was followed by a paper entitled

Cast Iron Under Impact.

By W. J. Keep, Detroit, Mich.

The object of the experiments described in this paper was to determine the influence of shock upon cast iron.

The kind of shock considered is a blow, which shall not produce distortion, delivered on a test bar. Blows were delivered by hammers of various weights, on different parts of test bars, and also by dropping test bars 3 ins. and allowing them to strike endwise on an anvil. Test bars were also subjected to shock by tumbling them in a tumbling barrel. The following observations were made:

Striking Test Bars on the Side Decreases their Length.—The decrease is so small that it is difficult to eliminate errors in taking measurements. The average of 19 pairs of bars shows that 10 blows with a ½-pound hammer on the side of a test bar ½-in. square by 1 ft. long shortens it .0001-in.

Four test bars ½-in. square × 12 ins. long, protected by two thicknesses of thin sheet iron from all contact with other castings, were placed in a tumbling barrel for 3 hours. The average shortening was 0.00065 in. The ends were protected from wear.

Other tests indicated the following: Blows on the end of a test bar shorten it. Test bars tumbled in contact with other bars increase in length. Tumbling bars in a barrel strengthens them. This confirms the results obtained by Mr. A. E. Outerbridge, published in Trans. Am. Inst. Mining Engineers in 1896, and in Eng. News, Feb. 27, 1896. Of the tumbled bars the weakest are strengthened the most, and the strongest bars are strengthened very little.

The strength gained by tumbling is due to making the surface of the test bar smooth and to condensing the surface by peening. The removal of the surface weakens a test bar. Smoothing the surface of a test bar without removing the surface strengthens it. Smoothing the surface of a test bar by pounding with a hammer increases its strength. Pounding the surface of a test bar strengthens it by condensing the grain.

A written discussion of this paper was presented by Mr. Strickland L. Kneass. He criticised Mr. Keep's paper for several apparent contradictions in it. He said that the results of the tests were not thoroughly digested, and that the experiments were carried on in too narrow lines.

At the session on Thursday evening the first paper presented was entitled

A Strength of Gear Chart.

By John B. Mayo, Brooklyn, N. Y.

The author takes the well-known formula of Mr. Wilfred Lewis for strength of gear teeth, and constructs from it a chart by which the pitch, face, etc., of a gear for any given case may be determined more easily than by calculation from the formula. The chart was first used, in its original form, by the Crocker-Wheeler Electric Co. The chart as engraved for the paper is condensed into a single page, and the lines are so close together that they can be followed only with great difficulty. The chart may be of value in many drafting offices where gear wheels are designed, but it will need to be re-drawn on a large scale.

A written discussion was presented by Mr. C. L. Griffin, who furnished another gear chart which appears to be simpler in form than Mr. Mayo's. It was also based upon Mr. Lewis's formula.

The next paper was entitled

The Law of Hydraulic Obstruction in Closed Streams.

By David Guelbaum, Syracuse, N. Y.

The class of phenomena considered is described in the introduction to the paper as follows:

A stream is enclosed in a conduit casing with an upset, or change of section, and passes around an obstruction placed at some distance from the upset. Notwithstanding the frequency with which these phenomena are met with in practice, they have been and are still a problem standing, as yet, unsolved; and even in the simple case of a stream within a clear pipe passing around a flat baffle, the contraction of the stream and its effective pressure upon the baffle are as yet unknown both experimentally and theoretically. The establishment, therefore, of a law governing these phenomena, or of a general property common to all of them and affording a basis for a general solution of these problems, would be a decided gain. After certain investigations, I discovered such a common and very remarkable property, which I would call the "law of hydraulic obstruction in closed streams." I see no other way of demonstrating that law but by rendering here the method of investigation which led me to its discovery.

Then follows eleven pages full of the most difficult mathematics, including algebraic expressions, containing as many as ten terms, and applications of the principle of least work and of the calculus, resulting in an equation concerning which the author says:

It is this equation which I believe to represent the general law of hydraulic obstruction in closed streams. Expressed in words, it says: If an obstruction placed within a stream enclosed in a casing with an upset is changing its position from the limit distance h_0 to the distance h towards the upset, causing thereby a certain variation in the quantity of motions of the contracted stream around the obstruction, then the difference between the full pressure upon the obstruction and the direct pressure upon it due to loss of height only, equals twice the part of the variation in the quantity of motion that reacts upon the area of the obstruction, plus a certain constant; pressures and loss of height mentioned being those due to presence of obstruction only.

No one had any desire to attack the formidable mathematics of this paper, and it was passed over in silence. Mathematical papers may be good things to print in the Transactions, but they cannot be satisfactorily discussed in the Society's meetings.

The Boiler Test Committee's "Draft of Report." was then taken up for discussion.

In 1885, twelve years ago, the Society published a standard code for tests of steam boilers. This code, while admirable at the time it was adopted, has become by the lapse of years confessedly inadequate in some respects for boiler tests made under conditions of the present day. Two years ago a committee was appointed to revise this code, and this committee submitted a preliminary report at the present meeting with requests for criticisms and suggestions. This preliminary report opened by calling attention to the improvements made in instruments for measuring the moisture in steam, testing the calorific value of fuels, analyzing flue gases, etc. In the new code, a draft of which was submitted with the report, the old code is amended where reference is made to these matters so that it reads as follows:

XIII. Quality of Steam.—The percentage of moisture in the steam should be determined by the use of either a throttling or a separating steam calorimeter. The sampling nozzle should be placed in the vertical steam pipe rising from the boiler. It should be made of ½-in. pipe, and should extend across the diameter of the steam pipe to within half an inch of the opposite side, being closed at the end and perforated with not less than twenty ⅛-in.

TABLE II.—Equipment of the Stations Showing the Maximum and Minimum Economy.

Year.	Economy.	Boilers.	Engines.	Dynamos.	Daily output, watt-hrs.	Fuel.
1894.	Maximum (208)	.....	.....	Arc, power and incandescent.	7,971,000	Coal, hard screenings.
1894.	Minimum (25)	.....	.....	Arc and incandescent.	80,670	Coal.
1895.	Maximum (262)	Horizontal water tube.	Triple expansion condensing.	Direct connected.	22,967,952	Half s'ft coal, half h'rd screenings.
1895.	Minimum (36)	Horizontal tubular.	High-speed non-condensing.	Belted direct.	2,790,565	Bituminous pea.
1896.	Maximum (237)	Horizontal tubular.	High-sp'd comp. condensing.	Belted direct.	3,270,392	Bituminous lump.
1896.	Minimum (33)	Horizontal tubular.	High-speed condensing.	Belted direct.	203,555	Anthracite buckwheat.
1897.	Maximum (269.5)	Water tube.	Vert. comp. con. four-valve.	Direct-connected incandescent.	.....	.....
1897.	Minimum (98.7)	Horizntl. tubular and w. tube.	Comp. condnsg. Comp. condnsg.	Belted to dynamo. Belted to countershaft	.....	Screenings.

holes equally distributed along and around its cylindrical surface, but none of these holes should be nearer than ½-in. to the inner side of the steam pipe. The calorimeter and the pipe leading to it should be well covered with felting. Whenever the indications of the throttling or separating calorimeter show that the percentage of moisture is irregular, or occasionally in excess of 3%, the result should be checked by a steam separator placed in the steam pipe as close to the boiler as convenient, with a calorimeter in the steam pipe just beyond the outlet from the separator. The drip from the separator should be caught and weighed, and the percentage of moisture computed therefrom added to that shown by the calorimeter. Superheating should be determined by means of a thermometer placed in a mercury well or oil well inserted in the steam pipe.

XIV. Sampling the Coal and Determining Its Moisture.—As each barrow or fresh portion of coal is taken from the coal pile, a representative shovelful is selected from it and placed in a barrel or box in a cool place and kept until the end of the trial. The samples are then mixed and broken into pieces not exceeding 1 in. in diameter, and reduced by the process of repeated quartering and crushing until a final sample weighing about 5 lbs. is obtained, and the size of the larger pieces are such that they will pass through a sieve with ¼-in. meshes. From this sample two one-quart air-tight glass preserving jars, or other air-tight vessels which will prevent the escape of moisture from the sample, are to be promptly filled, and these samples are to be kept for subsequent determinations of moisture and of heating value and for chemical analyses. During the process of quartering, when the sample has been reduced to about 100 lbs., a quarter to a half of it may be taken for an approximate determination of moisture. This may be made by placing it in a shallow iron pan, not over 3 ins. deep, carefully weighing it, and setting the pan in the hottest place that can be found on the brickwork of the boiler setting or flues, keeping it there for at least 12 hours, and then weighing it. The determination of moisture thus made is believed to be approximately accurate for anthracite and semi-bituminous coals, and also for Pittsburg or Youghiogheny coal; but it cannot be relied upon for coals mined west of Pittsburg, or for other coals containing inherent moisture. For these latter coals it is important that a more accurate method be adopted. The method recommended by the committee for all accurate tests, whatever the character of the coal, is described as follows:

Take one of the samples contained in the glass jars, crush the whole of it by running it through an ordinary coffee mill adjusted so as to produce somewhat coarse grains (less than 1-16-in.), thoroughly mix the crushed sample, select from it a portion of from 10 to 50 grams, weigh it in a balance which will easily show a variation as small as 1 part in 1,000, and dry it in an air or sand bath at a temperature between 240° and 280° F. for one hour. Weigh it and record the loss, then heat and weigh it again repeatedly, at intervals of an hour or less, until the minimum weight has been reached and the weight begins to increase by oxidation of a portion of the coal. The difference between the original and the minimum weight is taken as the moisture. This moisture should preferably be made on duplicate samples, and the results agree within 0.3 to 0.4%, the mean of the two determinations being taken as the correct result.

If the coal contains an appreciable amount of surface moisture, another portion of the 100-lb. sample should be weighed and spread out in a thin layer on a clean sheet-iron plate, and exposed for a period of 24 hours to the atmosphere of the boiler-room, and by this means air dried. After being weighed again, the percentage which the weight shrinks during this drying may be termed the percentage of surface moisture.

XVI. Calorific Tests and Analysis of Coal.—The quality of the fuel should be determined either by heat test or by analysis, or by both.

The rational method of determining the total heat of combustion is to burn the sample of coal in an atmosphere of oxygen gas, the coal to be sampled as directed in Article XIV. of this code.

The chemical analysis of the coal should be made only by an expert chemist. The total heat of combustion computed from the results of the ultimate analysis should be obtained by the use of Dulong's formula (with constants modified by recent determiniations), viz.: $14{,}600\ C + 62{,}000\left(H - \frac{O}{8}\right)$, in which C, H, and O refer to the proportion of carbon, hydrogen and oxygen respectively, and determined by the ultimate analysis.*

It is recommended that the analysis and the heat test be each made by two independent laboratories, and the mean of the two results, if there is any difference, be adopted as the correct figures. It is desirable that a proximate analysis should also be made to determine the relative proportions of volatile matter and fixed carbon in the coal.

XVII. Analysis of Flue Gases.—The analysis of the flue gases is an especially valuable method of determining the relative value of different methods of firing, or of different kinds of furnaces. In making these analyses great care should be taken to procure average samples—since the composition is apt to vary at different points of the flue, and where complete determinations are desired, the analyses should be intrusted to an expert chemist. For approximate determinations the Orsat or the Hempel apparatus may be used by the engineer.

XVIII. Smoke Observations.—It is desirable to have a uniform system of determining and recording the quantity of smoke produced where bituminous coal is used. The system commonly employed is to express the degree of smokiness by means of percentages dependent upon the judgment of the observer. The committee does not place much value upon a percentage method, because it depends so largely upon the personal element, but if this method is used, it is desirable that, so far as possible, a definition be given in explicit terms as to the basis and method employed in arriving at the percentage.

XX. Calculations of Efficiency.—Two methods of defining and calculating the efficiency of a boiler are recommended. They are:

1. Efficiency of the boiler = $\frac{\text{Heat absorbed per lb. combustible}}{\text{Heating value of 1 lb. combustible}}$.

2. Efficiency of the boiler and grate = $\frac{\text{Heat absorbed per lb. coal}}{\text{Heating value of 1 lb. coal}}$.

*Favre and Silberman give 14,544 B. T. U. per pound carbon; Berthelot, 14,647 B. T. U. Favre and Silberman give 62,032 B.T.U. per lb. hydrogen; Thomsen,61,816 B.T.U. (Appendix XV.)

The first of these is sometimes called the efficiency based on combustible, and the second the efficiency based on coal. The first is recommended as a standard of comparison for all tests, and this is the one which is understood to be referred to when the word "efficiency" alone is used without qualification. The second, however, should be included in a report of a test, together with the first, whenever the object of the test is to determine the efficiency of the boiler and furnace together with the grate (or mechanical stoker), or to compare different furnaces, grates, fuels or methods of firing.

The heat absorbed per lb. of combustible (or per lb. coal) is to be calculated by multiplying the equivalent evaporation from and at 212° F. per lb. combustible (or coal) by 965.7.

In calculating the efficiency where the coal contains an appreciable amount of surface moisture, allowance is to be made for the heat lost in evaporating this moisture by adding to the heat absorbed by the boiler the heat of evaporation thus lost. The percentage of surface moisture used in this calculation is that which is found in the manner described in Article XIV. of Code.

XXI. The Heat Balance.—An approximate "heat balance" or statement of the distribution of the heating value of the coal among the several items of heat utilized and heat lost may be included in the report of a test when analyses of the fuel and of the chimney gases have been made. It should be reported in the following form:

Heat Balance, or Distribution of the Heating Value of the Combustible.

Total Heat Value of 1 lb. of Combustible, ...B. T. U.

	B.T.U.	Per cent.
1. Heat absorbed by the boiler = evaporation from and at 212° per lb. of combustible × 965.7.		
2. Loss due to moisture in coal = per cent. of moisture referred to combustible ÷ 100 × [(212 — t) + 966 + 0.48 (T — 212)] (t = temperature of air in the boiler-room, T = that of the flue gases).		
3. Loss due to moisture formed by the burning of hydrogen = per cent of hydrogen to combustible ÷ 100 × 9 × [(212 — t) + 966 + 0.48 (T — 212)].		
4.* Loss due to heat carried away in the dry chimney gases = weight of gas per lb. of combustible × 0.24 × (T — t).		
5.† Loss due to incomplete combustion of carbon = $\frac{CO}{CO_2 + CO}$ × $\frac{\text{per cent. C in combustible}}{100}$ × 10,150.		
6. Loss due to unconsumed hydrogen and hydrocarbons, to heating moisture in the air, to radiation, and unaccounted for.		
Totals		100.00

* The weight of gas per lb. of carbon burned may be calculated from the gas analyses as follows:

Dry gas per lb. carbon $= \frac{11\ CO_2 + 8\ O + 7\ (CO + N)}{3\ (CO_2 + CO)}$, in which

CO_2, CO, O, and N are the percentages by volume of the several gases. As the sampling and analyses of the gases in the present state of the art are liable to considerable errors, the result of this calculation is usually only an approximate one. The heat balance itself is also only approximate for this reason, as well as for the fact that it is not possible to determine accurately the percentage of unburned hyrrogen or hydrocarbons in the flue gases.

The weight of dry gas per lb. of combustible is found by multiplying the dry gas per lb. of carbon by the percentage of carbon in the combustible, and dividing by 100.

† CO_2 and CO are respectively the percentage by volume of carbonic acid and carbonic oxide in the flue gases. The quantity 10,150 = number of heat units generated by burning to carbonic acid 1 lb. of carbon contained in carbonic oxide.

The remainder of the report is taken up with the form for reporting results, and with 38 appendices signed by the initials of the individual members of the committee to whom their preparation was assigned. The whole report, with the appendices, makes a pamphlet of 62 pages.

A very long discussion of the report took place, many of the members presenting suggestions for the consideration of the committee in its final revision, and some finding fault with some of its clauses. Two members said that the minimum length of a boiler test should be from 50 to 72 hours, the committee's report specifying a minimum of 10 hours. On the whole, the report was highly praised, and with a few minor alterations it will, no doubt, be finally adopted as the Society's standard code for boiler testing.

The New National Electrical Code of Rules.

and requirements for installations of apparatus and wiring was then presented by Mr. C. J. H. Woodbury, secretary and treasurer of the National Conference on Standard Electrical Rules. This code is the result of two years' work by a conference of delegates from fire insurance, electric, engineering, street railway, and architects' associations, including the Mechanical Engineers' Society, and it has already been generally adopted as the standard American code. It was received without discussion.

At the session on Friday morning a short paper was presented by Mr. Geo. W. Bissell, entitled "A Boiler Setting." It showed a method of suspending a horizontal tubular boiler from three points, by which it is freed from strains due to settling of the columns or setting. The rear end of the boiler is carried by two hangers to an overhead equalizing beam which rests on a roller placed on an I-beam, which is supported by columns built in the brickwork. The paper received no discussion.

The next paper was entitled

Auxiliary Engines and Transmission of Power on Naval Vessels.

By Geo. W. Dickie, San Francisco, Cal.

We abstract the following from the introduction:

Unfortunately, on government vessels, the work which has to be done by machinery is divided up and placed under the cognizance of various bureaus, each having a decided preference for some particular mode of transmitting power, which might really be the best for the particular work of that bureau, but not applicable at all to the class of work under the cognizance of another bureau, the result being that in one ship we are very likely to find three different methods of transmitting power in use, and no one in charge master of any one method.

Electric power is generated for lighting purposes, for controlling search lights, operating small fans for special purposes, and for signal purposes. In quite a large number of vessels electric power is used to operate ammunition hoists, and in one or two recent cases the lighter turrets have been operated by electric motors. In some vessels now building a further extension of electric transmission of power is being made to include the large turrets and all the gun-mount movements of the large guns. So that we now have the Ordnance Bureau fairly committed to this method of transmission.

In some of our ships the distribution of power is divided between electric and hydraulic transmission, the main battery being operated, including the turrets, by hydraulic power, while the ammunition for all secondary guns is served by electric hoists. While in others, the battleship "Oregon" being a good example, the main turrets and their guns are not only entirely operated by hydraulic motors, but all ammunition hoists throughout the ship, battle doors, etc., are worked from the same source of power. This vessel is also fitted with hydraulic steering gear.

Compressed air has been used to some extent as a means of transmitting power on some of our vessels, and is provided on all vessels carrying torpedoes for charging these intricate self-propelling projectiles.

Colonel Soliani, Chief Engineer of the Italian Navy Department, has strongly advocated compressed air as a means of transmitting power for all purposes on warships, except for operating large turrets, for which he prefers hydraulic power.

There are also those who advocate the use of steam direct on all auxiliaries, including the working of all turrets, ammunition hoists, and even the manipulation of the guns. The Bureau of Steam Engineering naturaly favors this direct application of steam as the most economical method, in power used, in weight, and in efficiency.

In the present state of the art of transmitting power to all parts of a modern warship it is not possible to compare one method with another as a whole, and from actual experience, there being no one ship with a complete system of transmission from a central generating station of one type to compare with another ship having an equally complete system from a central generating station of another type.

The author then discusses at length the merits and demerits of each of the different systems, and concludes as follows:

This paper does not aim to show the superiority of any one system over another, the comparisons made being simply to show that there is no mechanical difficulty in operating all auxiliaries by any one of the systems herein mentioned, and to express a hope that our government would either adopt some one system and carry it out complete, developing that system to its utmost efficiency or else take one or two similar ships and fit them with power transmission systems completely representing different agents—say one electric, one hydraulic, and one compressed air. Let each be placed for three years in the hands of officers heartily in favor of the system in use on their own ship, and thereby obtain a practical demonstration of the very best points in each system.

While we have hitherto advocated with all the ability we posses a complete hydraulic system, our experience in the practical working of hydraulics on shipboard has not been of the most pleasant character. Officers are required to care for and get the best out of a hydraulic system, while personally they would rather sit up all night with an electric light plant than spend a moment more than the law requires with a water motor.

The future hopes of the young officer are centered in electricity, and he devotes himself to it with a will; and so long as that condition prevails, the electric method of transmission will have the best chance to succeed, because with that it has a flexibility and a general adaptability which the other systems do not in themselves possess.

The paper was briefly discussed by Mr. H. H. Suplee, who showed one possible cause of danger in the use of a compressed air system of transmitting power in vessels, viz.: that of forming an explosive mixture of air and the vapor from the lubricant in the cylinder of the air motor, and its explosion by the heat of compression or by friction of the motor.

The next paper was entitled

"An Accurate Cost-keeping System."

By H. M. Norris, Cincinnati, O.

This paper described the system of keeping factory costs used by the author, its principal features being the monthly summary of general expense account, and its apportionment to the productive labor cost by the method of adding to the hourly wage of each workman an equal amount per hour, irrespective of whether the workman received a high or a low wage. Considerable discussion followed the paper, different members giving the plans of cost-keeping which they had found successful. The plan of including in the factory expense account the cost of distribution of the product, which cost properly belongs to the selling department, was strongly objected to.

The next paper was entitled

Thermodynamics Without the Calculus.

By George Richmond.

This paper is the result of a discussion which took place at the Hartford meeting in which Mr. Richmond stated

that a knowledge of the calculus is not necessary to an understanding of thermo-dynamics. He reiterates the statement in the present paper in the following words:

The contention is simply that the use of the calculus is no more essential to an intelligent use and understanding of such thermodynamic problems as ordinarily concern the engineer than it is necessary in order to find the horse-power of an engine from the indicator diagram.

The method the author uses is that of the temperature-entropy diagram, which he says is, on account of its extreme simplicity, coming more and more with general use. The paper is not of such a nature that a satisfactory summary or abstract can be made of it.

The paper was briefly discussed by Mr. William Kent, who said that what was wanted was a more elementary or "kindergarten-like" treatment of the subject of the entropy-temperature diagram than Mr. Richmond's paper gave, although the paper was highly commendable as far as it went.

The Valuation of Textile Manufacturing Property.

By Chas. T. Main, Boston, Mass.,

Was the subject of the next paper. The purpose and scope of the paper are shown in the introduction, as follows:

The engineer is called upon to place valuation upon manufacturing property for various purposes, as buying or selling, raising money upon or bonding a property, rental, taxes, insurance, adjustment of losses by fire or accident, and condemnation where private or corporate property is taken by the state or town for public improvements.

I shall confine my remarks to the valuation of textile manufacturing plants, and property usually connected therewith; but the same principles will hold good in the value of other properties, the application being made to suit the peculiar conditions of the business under consideration.

The paper makes a pamphlet of 30 pages, and includes elaborate discussions of the questions of market value; physical properties and value of a plant; valuation for bonding or raising money; valuation for rental; valuation for taxes; valuation for insurance and adjustment of fire losses; valuation for purposes of condemnation. We advise those of our readers who may be interested in the question of valuation of factory property to obtain a copy of Mr. Main's most able paper.

The paper was discussed by Messrs. Woodbury and Rockwood. It was followed by a paper on

Electricity in Cotton Mills.

By W. B. Smith Whaley, Columbia, S. C.

It is the purpose of this paper to attempt to describe from the actual operation of two plants working under nearly identical conditions the one operated by rope transmission and the other by means of motors distributed throughout the building. In one the actual operation of the steam engine is considered, in the other the current is supplied to the motors from the secondary switch-board or receiving station.

Mill No. 1 is a steam-driven mill, having a steam plant, geared up with ropes, heavy head gearing and large tapering shafts as such plants are usually geared up in the best practice of to-day. The steam engine is an 800-HP. Corliss cross-compound, with cylinders 20 and 40 by 60 ins. stroke, and a rope wheel 24 ft. pitch diameter, grooved for 26 1¾-in. ropes, weighing 35 tons. There was in the mill during the period for which comparison of power is made 11,776 spindles and 720 looms; all the spindles and preparatory machinery were run full, but the looms did not average more than 682 per day. Mill No. 2 is an electric-driven mill which rents its current from a central station and distributes it through a continuous-reading wattmeter to four 150-HP. inverted motors bolted to the ceiling in convenient locations for economical distribution of the power, and belted to the shafting. This mill had in operation during the period named on an average 12,448 spindles, with preparatory machinery, and an average of 356 looms out of 500 in the mill. The weight of the shafting in the steam mill is approximately 136,000 lbs., and in the electric mill 122,000 lbs.

From a diagram showing the power curves in the two mills, from April 1 to June 25, 1897, we find that the average in the steam mill is 535.71 HP. for all purposes. From indicator cards taken, we find that the power required to drive the shafting and belting on loose pulleys only is 228 HP.; for the 720 looms and shafting only, 349 HP.; and for the whole mill, 505 HP. Deducting the friction HP. from the power required to drive the looms and shafting and dividing this result by the number of looms, we obtain the power required to drive one loom, which is 0.168 HP.

Deducting the power required to drive the looms and shafting from the total power gives us 246 HP., which is the power required to drive the spindle and preparatory machinery. This amount divided into the number of spindles gives us 60 spindles per HP., including the necessary preparatory machinery for this number of spindles.

In the electric mill, owing to the lack of suitable instruments for testing the separate motors, we were unable to find the amount of power expended in friction, and consequently, having only the average power consumed, we can compare the mills by using the data obtained from the steam mill to bring the electric mill to the same basis. From the power chart we observe that on an average 418.2 HP. per day were used in the electric-driven mill during the period above alluded to.

From the data obtained from the steam-driven mill we have the following distribution of power during the test—for the steam-driven mill,

Total power.	Looms and shaftg.	Friction.	Spindles.	Looms.
535	340	226	196	114

and for electric-driven mill,

Total power.	Looms and shaftg.	Friction.	Spindles.	Looms.
418	206	149	208	60

In the discussion it was stated that the apparent saving in friction of 77 HP. in the electric driven mill could not be due simply to the use of electricity. There must be some other cause for the saving, such as better lining of shafting, better lubrication, etc.

The next paper considered was entitled

A Screw Die for the Turret Lathe.

By James Hartness, Springfield, Vt.

The object of this paper is to submit a description of a screw-cutting die, possessing certain novel features. This die is intended for turret lathe and screw machine use, but may be used on any machine in which the work is rotated.

The die head proper has a slight lateral and angular freedom of movement related to its holder, the object being to compensate for a slight change in alinement in the lathe or machine on which the die is used, that takes place when the torsorial strain of working takes up the slack of the sliding parts.

The chasers are held in working position by an encircling cam which takes bearing directly over and very close to the front or working teeth, preventing canting of the chaser under working strains. The shape and dimensions of this cam make it unyielding in its control of the diametrical position of the chaser.

The form of the chaser teeth plays an important part in the free cutting and accurate leading of the die. The teeth at the front of the chaser have a cutting clearance, while the teeth at the back of the chaser have no clearance, but instead, ride on the thread and control the lead. This gives the cutting teeth an ideal cutting clearance on each side of each tooth and relieves these teeth of the labor of feeding to the die forward.

So accurate is the lead-controlling feature that regular dies for market seldom have an error in lead greater than 1-64-in. in 18 ins., which is less than one-quarter the average error in standard taps, and less than one-half the error in 90% of the engine lathes. Thus it is more accurate than the average lead screw and always practically sure, being made by methods insuring invariable accuracy of product and most perfect interchangeability.

The chasers are milled separately in special milling machines using milling cutters of large diameter, having teeth arranged around in circles instead of in the path of a screw-thread. These milling cutters are given an ideal cutting clearance in backing-off lathes, and after hardening are ground to a cutting edge suitable for taking a clean chip, so that the teeth of the chaser can be formed without that rubbing or burnishing which always accompanies the hobbing or tapping of the other dies or chaser.

All tapped or hobbed dies have practically four errors. First, the lead screw error of the engine lathe in which the tap or hob is made. Second, the error of hardening the tap or hob. Third and fourth, the double error of changing form of the die in hardening it, due to releasing the compressed metal, and the usual hardening change that takes place at the same time.

By the use of the present method, all errors existing in the milling cutter are corrected in the milling machine, hence the lead is only affected by the final hardening of the chaser, which takes place under such favorable conditions that it produces no appreciable effect.

A sample of the screw die described in the paper was exhibited. Mr. Hartness also presented another paper entitled

A Stay Bolt Threading Device.

This paper describes a means for threading stay bolts.

The scheme may be described as tandem dies for simultaneously threading both ends of a stay bolt to insure an accurate correspondence in lead; the details of which are means for accurately adjusting the relative longitudinal position of the dies and employment, of at least for the forward die, of some type of opening die of not too great length and not too inaccurate in lead, and possessing good diameter controlling features.

Both dies employed should be of the opening type, but the scheme would be equally as accurate if a solid or non-opening die were to be used in the place of the rear die.

The plate to which the dies are affixed is not necessary when the scheme is used in the flat turret lathe, for in that machine the dies may be attached directly to the turret without the use of the plate.

Mr. A. L. Rice's paper on a

"Convenient Form of Wire Testing Machine"

was presented without discussion. The machine described in the paper consists of a spring balance of 200 lbs. capacity, with a large dial, a pulling device comprising a screw running in a long nut and driven through a spur and pinion gear and a hand wheel, and pulling clamps of ordinary designs for small machines. Twelve such machines were built at a total cost of $380, and they have given excellent satisfaction.

This was followed by Mr. C. J. H. Woodbury's paper on "Dustless Buildings," which is printed elsewhere in this issue.

The next paper was a historical one:

The Stevens Valve Gage for Marine Engines.

By Andrew Fletcher, Hoboken, N. J.

Mr. Fletcher is a member of the firm of W. & A. Fletcher Co. and engaged in ship and engine building, and has had experience in the use of the Stevens valve gear for 44 years. The gear was invented in 1833 by Mr. Francis B. Stevens, who is still living in his 87th year. In order to place on record the history of the invention, Mr. Fletcher has obtained two very interesting letters from Mr. Stevens, which form the body of the paper. We quote the following extracts from one of the letters:

Previous to its introduction, in the year 1840, the form of valve and valve gear in almost universal use on the steamboats navigating the rivers and bays of the Atlantic coast was by poppet valves, operated by a single eccentric and a single rock shaft, the admission and exhaust of steam being coincident. Expansion was effected by a butterfly valve on the steam pipe worked by cams on the shaft, which was called the camboard cut-off. On the Mississippi, at the date mentioned, the engines were the same as at present in use, having poppet valves worked by cams on the main shaft.

In the latter part of the year 1839 I invented the Stevens cut-off, and early in the year 1840 I had the machinery for its application on the engine of the steamboat "Albany" made. This vessel was owned by my father, and the machinery was made by H. R. Dunham & Co., North Moore St., New York.

My uncle, Robert L. Stevens, proposed an improvement by substituting a cog wheel for the arm of the rock shaft, by which a greater angular motion of the rock shaft, and consequently a shorter cut-off, could be obtained. We then agreed to take out a patent in our joint names, with the understanding that I was to have complete ownership of the patent. The patent was granted on the 25th of January, 1841, the claims being as follows:

1. "The combination of an additional and separate eccentric wheel to work a rock shaft to raise the steam valves in combination with any of the several methods hitherto used for working the exhaust valves.

2. "The manner in which the toes are affixed to the rock shaft so that the shaft is made to vibrate during a certain interval, without either toe communicating motion to either valve.

3. "The connection of the cog wheel and rack, in the manner set forth, for the more completely effecting our object." This connection was never used, being found unnecessary.

The patent was renewed in 1855 and expired in 1869. Its validity was never attacked, and none of its claims was infringed during the twenty-one years of its existence. The Stevens patent, whether under the combined first and second claims or under the first claim alone, can be said to have been in universal and exclusive use on all beam-engine paddle-wheel steamboats in the United States since the expiration of the patent 35 years ago. Of late years the substitution of the screw, with its quick-moving engine and slide-valve, has superseded the paddle and poppet valve on the ocean; and also in great part on the rivers of the Atlantic coast, and on the Great Lakes.

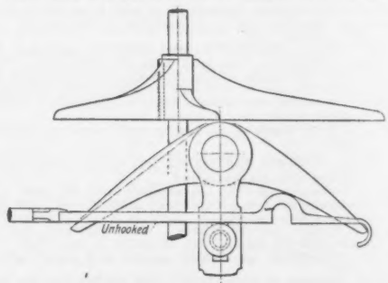
Although Watt invented and patented the double-acting rotative steam engine in his second patent, dated 25th of October, 1781, and although he made many of these engines, of many different sizes, and was in fact the only maker of them in the world during the long period that elapsed between their introduction and the expiration of his extended patent in the year 1800, he never used steam expansively on a rotative engine. The engine that Fulton bought from Watt in 1805-6, and which he placed on the "Clermont" in 1807, was operated by Watt's hand-gear, as shown on plate XIII. of Farey's Treatise on the Steam Engine.

It was very ingenious, but complicated, made almost entirely of steel tempered blue, and was operated by tappets and detents. No modification of Watt's hand-gear, to enable it to cut off the steam on a rotative engine, was ever made by him or by others. The engines of all the numerous vessels that Fulton built were copies of the one he bought from Watt.

I frequently saw Watt's hand-gear in operation; and remember on one occasion seeing the detents fail and the engine instantly stopped. No lead could be given by the hand-gear; and the cranks were carried past the centers by a fly-wheel. All of Fulton's steamboats had fly-wheels geared two to one, thus increasing the force of momentum fourfold.

In the year 1814 Robert L. Stevens built the steamboat "Philadelphia" on the Delaware, the engine having Watt's hand-gear. And in the year 1817 he invented the camboard cut-off, and attached it to this engine as a separate cut-off. This was made by a butterfly valve placed on the steam pipe at its junction with the steam chest, and operated by two cams on the main shaft, pressing against the camboard and connected to the butterfly valve, and to a strong spring on its arm by a rod about half an inch diameter. The length of the cut-off corresponded to that of the cams, and the motion was exceedingly rapid. He at the same time increased the pressure from 2½ to 10 lbs. per square inch. This cut-off was very successful and remained in use on all low-pressure steamboats in this country long after the hand-gear of Watt had been superseded by the eccentric of Murdock, and up to the introduction of the Stevens cut-off in 1840.

The accompanying cut shows the toes and wipers used in the Stevens gear on the steamers "Albany" and "New York." Their shape will be familiar to all who have



Toes and Wipers in Stevens Cam Valve Gear on Hudson River Steamers "Albany" and "New York."

traveled by the paddle-wheel steamers on the Hudson River or Long Island Sound. In the conclusion of his paper, Mr. Fletcher says:

Not long since the writer was upon a steamer in New York harbor, for which he had made a new cylinder and front in 1855, and had then applied the Stevens gear. It remains in good working order, and has given no trouble. With very fast running engines, the wipers are made slightly different in shape, and we put springs on the lifting rods so as to force the toes to follow down the wipers. But we have never had any trouble to make the cut-off work satisfactorily.

It was discussed by Messrs. J. C. Kafer and G. I. Rockwood, after which Mr. Fletcher gave some reminiscences of steamboating on the Hudson River, showing how the non-adjustable Stevens valve-gear frequently gave better results both in economy of coal and in speed of boat than the Sickels adjustable gear, on account of the difficulty of educating the engineers on the boats to the correct method of using the latter.

Mr. E. H. Mumford then presented a paper on "Machine Molding without Stripping Plates," of which we shall publish an abstract in a later issue. The reading and discussion of papers being concluded, the retiring president, Mr. Worcester R. Warner, spoke a few words of farewell, and brought to a close the most largely attended meeting ever held by an engineering society in the United States.